Science and Art Department
of the Committee of Council on Education.

CATALOGUE

OF

MODELS OF MACHINERY, DRAWINGS, TOOLS, &c.

IN THE

SOUTH KENSINGTON MUSEUM.

WITH CLASSIFIED TABLE OF CONTENTS
AND AN
ALPHABETICAL INDEX OF EXHIBITORS
AND SUBJECTS.

LONDON:
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
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SCIENCE AND ART DEPARTMENT,

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Science and Art Department
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CATALOGUE OF THE COLLECTION

OF

Models of Machinery, Drawings, &c. in the South Kensington Museum.

PREFACE.

THE collection of Models of Machinery was begun some twelve years ago, in connexion with the Models of Ships contributed to the Museum by private owners and shipbuilders.

At first models of Marine Steam Machinery only were included; but besides these the collection at present possesses valuable working Models and Drawings of many other kinds of machinery used for manufacturing or other purposes.

Since the first edition of the Catalogue of Models and Drawings of Machinery in the Museum was published in 1875, many additions have been made to the collection. These were chiefly obtained at the close of the Scientific Apparatus Exhibition of 1876 at South Kensington; from the Paris Universal Exhibition of 1878; and from exhibitors who have kindly lent many valuable and interesting objects.

The present collection of Models is, however, but a beginning. It is to be hoped that the assistance hitherto readily granted by engineers, machine makers, and owners of models to increase the number and variety of objects already in the Museum will be continued.

December 1879.

CLASSIFICATION

Of Models and Objects of Machinery in the South Kensington Museum.

CATALOGUE.

CLASS I.

Prime Movers.

LAND STEAM ENGINES.—FIXED ENGINES.

1. Four Horse-power, Inverted Cylinder, STEAM ENGINE; fitted with Vertical Tubular boiler, fly-wheel, Patent Feed-water Heater, &c.

Lent by Messrs. Davey, Paxman, and Co., Standard Works, Colchester. 1878.

Note.—This engine and its boiler stand on a bed-plate measuring 7 feet by 3 feet, forming a feed-water space or tank. The engine is entirely independent of the boiler. Its standard framing is firmly bolted to the bed-plate. The cylinder is 10 inches in diameter; stroke 12 inches. The fly-wheel is three feet six inches in diameter, and has a turned face five inches broad for a strap.

The boiler is 7 feet in height and 3 feet in diameter, and is fitted internally with tubes on the Paxman plan.

2. High speed Horizontal STEAM ENGINE, with fly-wheel, governor, and feed-pump, complete.

Lent by Messrs. J. Bourne and Co., 66, Mark Lane, E.C. 1878.

Note.—This small engine of four horse-power (indicated) runs at very high speed and thus developes its large amount of power. The high speed, about 500 revolutions per minute, is rendered possible by the momentum of the reciprocating parts being balanced by counter-weights, and by the wearing surfaces being all of extra size to prevent undue wear.

Mr. John Bourne, C.E., the patentee, has applied the same system to engines of considerable size. *See also pages* 13, 105.

3. Four Horse-power (Nominal) Horizontal High-pressure STEAM ENGINE. All the parts bright.

Messrs. Robey and Co., Engineers, Lincoln.

Lent 1879.

Note.—This engine was exhibited at the Paris Universal Exhibition of 1878. The diameter of the cylinder is seven inches, stroke 10 inches. The engine is fitted complete for working, save the fly-wheel. It has also Robey and Co's arrangements attached to the single eccentric which moves the slide-valve, for working the engine at various degrees of expansion or for reversing its motion either way.

The bed-plate is 6 feet 6 inches by 2 feet $3\frac{3}{4}$ inches square. The fly-wheel is 4 feet 6 inches diameter. Working steam-pressure 60lbs. per square inch. Indicated horse-power 15. Number of revolutions made by the engine, 130 per minute.

4. MODEL of Robey and Company's SEMI-PORTABLE HORIZONTAL ENGINE, for Mining purposes. Richardson's Patent.

Lent by Messrs. Robey and Co., Engineers, Perseverance Works, Lincoln. 1876.

Note.—This engine, designed on what is called the semi-portable system, comprises a locomotive engine, horizontal tubular boiler for high pressure, under which lies a horizontal double cylinder steam engine, which drives a large drum for winding purposes, and to which is also attached means for driving large pumps for pumping water from mines.

5. WORKING MODEL. Improved Horizontal High-Pressure COUPLED WINDING ENGINES. For hoisting. Applicable to coal, copper, iron, salt, and other mines.

Lent by Messrs. Robert Daglish and Co., St. Helen's Foundry, Lancashire. 1876.

6. WORKING MODEL. Vertical High-pressure STEAM ENGINE, with upright copper Boiler.

Lent by Mr. H. Sandham. 1872.

7. MODEL, in Wood. The Steam Cylinders, Slide Valves, and Steam Ports; in section. For Compound Engines.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—This model apparently represents the above arrangements for an engine of the horizontal cylinder type. The Model is imperfect.

8. WORKING MODEL. On about $\frac{1}{4}$-inch scale. A Horizontal High-pressure STEAM ENGINE. Reversing motion

on the link principle with two eccentrics, and crank formed by a disc-wheel or plate, and pin.

Lent by Mr. C. Pidgeon, 12, Ashurst Street, Park Road, Battersea. 1877.

Note.—This model represents a horizontal, high-pressure steam engine constructed on the modern principle of making the steam cylinder, steam chest, and slide-valve entirely independent of the bed-plate of the engine, to which it is attached by nuts and bolts. The steam cylinder, slide-valves, and steam chest are thus capable of being removed for overhaul and repair without interfering with the bed-plate. This model was made by Mr. C. Pidgeon, a student in the Science Schools at Draycott Street, S.W. It is fitted with fly-wheel, feed-pump, and reversing motion on the link principle, with double eccentrics; and the crank to the fly-wheel shaft is formed by a disc-wheel and pin, the most recent method adopted in this class of prime mover.

9. MODELS. Design for ROTARY STEAM ENGINES. Two Models.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—One of these models is a model in brass. The other is an experimental model in wood showing working parts.

10. WOOD MODEL of a DISC ENGINE.
Taylor and Davies' Patent, 1836.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

11. DRAWING, on a scale of 1½ inch to 1 foot. Patent Horizontal High-pressure CONDENSING STEAM ENGINE. Designed and made by the Reading Iron Works Co.

Lent by the Reading Iron Works Co., Limited, Reading. 1874.

Note.—This drawing shows a side elevation of the engine and a sectional plan.

It represents an engine of 25 horse-power nominal; having variable expansion gear, fly-wheel, governor, feed pump, and condenser.

A similar engine was employed to drive a part of the British Machinery in motion at the Vienna Universal Exhibition of 1873.

12. PHOTOGRAPHS. Two. — Compound Horizontal Cylinder Condensing STEAM ENGINE. 120 Indicated Horse-power. Constructed by the Donors in 1873.

Presented by Messrs. W. and J. Galloway, and Sons, Engineers, Knott Mill Iron Works, Manchester. 1874.

Note.—One Photographic view is of the cylinder end of the engine; the other shows the fly-wheel, crank-shaft and governor motion, etc.—

The high-pressure cylinder is 14 inches in diameter. The low-pressure cylinder is 24 inches in diameter. The stroke of the engine is 2 feet 6 inches.

This engine was employed in driving a portion of the British Machinery in motion at the Vienna Universal Exhibition of 1873.

13. PHOTOGRAPH of Brotherhood's Patent Three Cylinder High-pressure STEAM ENGINE. Arranged as a stationary engine. The engine was designed and patented by Mr. P. Brotherhood in 1872–73.

Presented by Messrs. Brotherhood and Hardingham, Engineers, London. 1874.

(*See also pages* 59, 85, 108.)

14. DRAWING of Head's Patent STEAM ENGINE.

Lent by Mr. Jeremiah Head, M.I.C.E., Middlesborough. 1876.

Note.—This drawing represents an inverted, direct-acting, non-condensing steam engine, with steam-jacketed cylinder and covers, cylindrical slide valves, and variable expansion gear; controlled by a liquid-cataract parabolic governor, and balanced throughout for running at a high speed. Designed March 1876. Scale of drawing 1½ inches to 1 foot.

15. PHOTOGRAPHS. NEWCOMEN'S STEAM ENGINE. From the original working model at the Glasgow University. About 1760. 1877.

Note.—This original model of Newcomen's engine, the property of the University of Glasgow, is a working model having boiler, steam cylinder, rocking beam of wood, piston and connecting rod, and pump rod. Newcomen devised this engine for pumping water from mines in the latter part of the 18th century.

This interesting model was lent to the Exhibition of Scientific Apparatus held at South Kensington 1876. In 1765 this model was repaired for the university by James Watt, at this time reputed for his skill in repairing steam engines. The many defects observed by Watt in the working of this engine led to the great improvements he effected in the detail of the steam engine, in which also the researches on the subject of heat, made by Dr. Joseph Black, born 1728, died 1799, Professor at Glasgow University, 1756, greatly assisted Watt.

The photographs (2) represent a right and left view of the model.

16. DRAWING, on a scale of 1 inch to 1 foot. Newcomen's PUMPING ENGINE. About 1760. From the original working model at the University of Glasgow.

Lent by Mr. T. Lidstone, per Mr. Bennet Woodcroft, F.R.S. 1877.

Note.—This drawing represents the same model referred to in preceding note to No. 15.

17. PHOTOGRAPH of an old ENGRAVING: Dated 1719. An early English engraving by T. Barney. The STEAM ENGINE near Dudley Castle. "Invented by Captain Thomas Savery and Mr. Thomas Newcomen." Erected by the latter in 1712.

Note.—This very old and interesting engraving of a Newcomen Steam Engine, the property of Mr. T. Dow of Exeter, connects the two names of Savery and Newcomen as the joint inventors of this pumping engine. It represents an elevation, giving the entire detail of all the working parts of the pump, boiler, and engine, with references thereto, lettered. It also shows a sectional elevation of the engine-house. This very rare engraving was lent by Mr. Dow of Exeter to the Scientific Apparatus Exhibition at South Kensington in 1876. In addition to the detail of the engine and its house, it represented the contemporary elevation of Dudley Castle.

Thomas Newcomen was born in the early part of the 17th century, and died in 1729. He was a blacksmith by trade, and was the inventor of the first self-acting steam engine, 1712.

Thomas Savery, a Cornish mining captain, lived at the end of the 17th century, and died in the beginning of the 18th century. In 1696 he patented a method for propelling vessels by paddle-wheels driven by manual labour. In 1698 Savery patented his first steam engine, and in 1705 he became a joint patentee with Thomas Newcomen and Mr. Cawley for a "steam atmospheric pumping engine."

18. HIGH SPEED Horizontal STEAM ENGINE. 25 nominal Horse Power. Constructed for the inventor, J. Bourne, C.E., and exhibitor, by Messrs. John Penn and Sons, Engineers, Greenwich, 1870.

Lent by Messrs. John Bourne and Company, 66, Mark Lane, E.C. 1879.

Note.—This 25 horse-power, high-pressure, high-speed steam-engine is fitted with Bourne's patent governor and is balanced for momentum by counter-weights. It runs at 400 revolutions a minute, the boiler steam-pressure being 120 lbs. per square inch. The diameter of the cylinder is 6 inches; length of stroke 10 inches; diameter of fly-wheel 30 inches; 8½ inches wide on face. The engine will develope 40 indicated horse-power. It has lately been employed in driving machinery at the Royal Polytechnic Institution.

Land Steam Boilers.

19. Sectional Model, in Brass. Showing the Tubular Arrangement, Water spaces and Circulation; of Richardson's Patent Vertical High-pressure Steam Boiler.

Lent by the Makers, Messrs. Robey and Co., Engineers, Lincoln. 1874.

19a. Drawing. Richardson's Patent Vertical High-pressure Tubular Steam Boiler. Robey and Co., Makers.

Lent by Messrs. Robey and Co., Engineers, Lincoln. 1874.

Note.—The drawing shows a sectional elevation indicating the water circulation and the direction of the fire and products of combustion. Also a sectional plan of the boiler.

20. Model, W. and J. Galloway and Sons' Patent Water Tube, Double-furnace flue, Cylindrical Boiler.

Lent by Messrs. W. and J. Galloway and Sons, Knott Mill Iron Works, Manchester. 1879.

Note.—This model represents one of the set of boilers by Messrs. Galloway, employed to drive the British machinery in motion at the Paris Universal Exhibition of 1878. The boilers were each 28 feet long, and 7 feet in diameter. They contained two furnace tubes, each 2 feet 9 inches in diameter, and 7 feet 6 inches in length, running into an oval-shaped back flue or chamber, containing 33 Galloway patent vertical water tubes, against which the products of combustion impinged. The boilers were capable of driving 300 indicated horse-power each, and their working pressure was 75 lbs per square inch. The model is made to open, and show the interior disposition of the Galloway water tubes in the boilers.

21. Working Model, Scale $\frac{3}{4}$ inch to 1 foot. Coleman's Patent Double-circulating Steam Boiler.

Lent by Messrs. Coleman and Morton, Engineers, London Road Works, Chelmsford, Essex. 1879.

Note.—The model represents an improved form of steam boiler of the elephant type, brought out in 1875–6, by Mr. Coleman, and in use at the works of Messrs. Coleman and Morton. The boiler consists primarily of two cylinders lying horizontally one above the other. The cylinders are connected together by short and long water tubes of conical shape ranged alternately the entire length of the cylinders. The long tubes extend deeply into the lower cylinder, the short tubes merely connect the two cylinders together. The bottom cylinder is entirely filled with water, so are the connecting tubes, whilst the upper cylinder is only half filled. On the top of it is carried a steam dome or chest. The water circulates from one cylinder to the other in a downward

direction through the long tubes, and in an upward direction through the short tubes. The furnace is placed underneath the lower cylinder. Its heat and products of combustion are carried by flues in the setting of the boiler backward and forward thrice for the entire length of the cylinders before passing out to the chimney. The model represents a boiler of 25 horse-power whose shells or cylinders are 18 feet long, and 3 feet in diameter.

22. DRAWING. Water-colour Drawing, Scale ½ inch to 1 foot. A Pair of Double-Flue, Tubular, Cornish BOILERS for High-pressure.—Adamson's Patent.

Presented by Messrs. D. Adamson & Co., Engineers, Hyde Junction, Manchester. 1874.

Note.—Two of these boilers were lent to H.M.'s Commissioners for the Vienna Universal Exhibition of 1873, for use in supplying steam to drive the British Machinery exhibited in motion.

The drawing shows front or firing end elevation of boilers; longitudinal elevation with brick setting.

Longitudinal sectional elevation, showing arrangement of flues; blow-off, feed, and other pipes. The brick settings.

Two cross sections.—One through centre of boilers; the other through back end, showing brick setting, flues, etc.

The system of constructing Cornish steam boilers, with double flues, was the invention of the late Sir William Fairbairn, Bart., born at Kelso 1789, died 1874, who constructed steam boilers on this plan at his works at Manchester, about 1840. Sir William also is credited with the foundation of the Manchester Steam Boiler Association, an insurance society, devised for inspecting periodically in behalf of employers of steam power, the boilers used by them, and of securing thereby their safety and durability.

23. DRAWING, on a ¾ inch to 1 foot scale. Howard's Patent Water-tube Land BOILER. For High-pressure.

Lent by the Patentees and Makers, Messrs. J. and F. Howard, Engineers, Bedford. 1874.

Note.—The drawing illustrates a front view of the boiler; longitudinal section and plan. Also a cross section.

On a scale of ¼ full size, is shown the detail of the water tube connexions.

These boilers are also made by the Barrow-in-Furness Ship-building Company.

See Marine Boilers—Howard's Patent, p. 29.

24. DRAWING, scale 1½ inches to 1 foot. Messrs. A. Chaplin and Co.'s Patent Vertical, Tubular, High-presure STEAM BOILER.

Presented by Messrs. Alexander Chaplin and Co., Engineers, Glasgow. 1874.

Note.—The drawing shows longitudinal Vertical sections. Two plans of the disposition of the upper and lower tubes.

25. DRAWING, sectional, scale 3 inches to 1 foot. An Improved Vertical High-pressure STEAM BOILER, having horizontal water tubes with "Nozzle" ends, to assist the water circulation. From the construction of the tubes with Nozzle ends this boiler is called the "Nozzle" boiler.

Lent by the Makers, the Reading Iron Works Company, Limited, Reading. 1874.

Note.—The drawing shows a through sectional elevation of the boiler, and a sectional plan of the arrangement of the tubes. It shows also the circulation of the water, together with the direction of the fire and products of combustion.

26. DRAWINGS. Dickenson and Mace's Patent Multi-Tubular Land and Marine STEAM BOILERS.

Constructed by Mr. J. Dickenson, Engineer, Sunderland. Lent 1876.

Note.—The drawings represent four distinct cross sections of these boilers. A side elevation, half section, and front elevation of them, and six detail plans of their arrangement and setting. The boilers are multi-tubular, two separate sets of tubes being arranged one above the other, through which the products of combustion must travel before reaching the uptake.

27. SECTIONAL MODEL, in Wood. Land STEAM BOILER, of the form known as an "Elephant" Boiler. German construction.—I. Schroeder, Darmstadt.

Note.—The model takes to pieces to show a cross section of its form, the construction of its setting, heating flues, &c.

See also No. 78, Part II., page 164.

28. TWO SPECIMENS of IRON BOILER PLATE. A. Atlas iron plate. B. Best iron plate for boilers.

From the Atlas Steel and Iron Works, Sheffield. 1864.

Note.—These specimens of boiler plate are in the Ship model collection. They are bent and broken, to show the quality and texture of the iron.

29. BOILER PLATE. Part of the Crown of the fire flue of a Cornish STEAM BOILER.

Presented by Messrs. Fraser Bros, Engineers, 98, Commercial Road East, E. 1877.

Note.—This specimen consists of two rivetted plates, which formed the crown of the fire flue of a Cornish steam boiler. The boiler collapsed some time since through want of sufficient water.

30. A set of Patent FURNACE BARS. For saving fuel, preventing the formation of clinkers, and assisting the combustion of fuel.

Lent by Mr. E. Newbold, 22, Low Pavement, Nottingham. 1879.

Note.—These furnace bars invented by Mr. E. Newbold differ materially from the bars in general use for steam boiler and other furnaces.

31. MODEL, illustrating a pair of Lancashire STEAM BOILERS furnished with J. Hopkinson and Company's Patent Valves and fittings for insuring the greater safety of large boilers.

Lent by Messrs. J. Hopkinson and Co., Engineers, Huddersfield. 1879.

Note.—The appliances for steam boilers lately brought out by Messrs. Hopkinson and Co. are, amongst other things, a patent self-acting steam check or isolating valve for cutting off automatically any one boiler of a series from the rest; and a patent mercurial safety valve for over pressure and lowness of water.

The mercurial check valve permits a full flow of steam in one direction, but effectually stops it in the opposite direction. So long as the steam in any one boiler to which it is attached is maintained, the valve will remain open; but when the steam ceases to flow through it from the boiler, and an equal pressure occurs on both sides of the valve, it will close gently and without impact, and thus isolate its own boiler from the others.

The mercurial safety valve for over pressure and lowness of water in boilers is substantially on the principle of a dead weight valve, but the specialty consists in the application of a balanced lever the action of which on the safety valve is controlled by a cup suspended on trunnions containing a quantity of mercury at one end of the lever, and having a column or stand pipe dipping into it. The action of the valve is as follows:—Suppose the steam pressure to be limited to 60 lbs. per square inch, at that pressure the valve will blow off in the ordinary way. The mercury in the cup and its column pipe is also adjusted for 60 lbs. pressure. All things are thus equal, and the safety valve is lifted by the steam pressure alone. Should the pressure however continue to rise above 60 lbs., then the mercury in the cup and column pipe begins to flow into a receiver on the top of this column pipe and so causes the cup suspended on one end of the lever to become lighter than its balance weight at the other and raise it, so as to bring a pair of lugs or tips into action against a collar fixed upon the valve spindle. The balance weight thus helps to lift the valve itself higher from its seat than it would be lifted by the steam pressure only.

By means of two balanced levers controlled by the action of the cup of mercury and its column already spoken of, the safety valve will act in relieving the boiler of steam pressure when suffering from lowness of water as well as from an over pressure of steam.

Coloured drawings of these safety arrangements for steam boilers and other fittings are exhibited by Messrs. Hopkinson and Co.

NOTE ON LAND STEAM BOILERS.

Steam boilers used in fixed positions for supplying steam to Prime Movers are of two descriptions.

The old form, in which the water was contained in the boiler in mass whilst the fire passed underneath and around it on the outside.

The modern form, in which the boilers are long cylinders lying on their sides horizontally and divided through the centre for the whole of their length by other iron cylinders called flues. In these flues the fire is placed at one end, and the heat and products of combustion pass along them and are conveyed by artificial channels around and under the boiler outside, and so to the chimney. There are also employed boilers known as tubular or multitubular.

In some instances the water in these multitubular boilers is made to circulate through a quantity of tubes placed inside it, and the fire and heat passes amongst them outside; or contrarywise, where the water in the boiler is outside the tubes and the fire and heat passes through them. A recent form of boiler, known as the water-tube boiler, consists of a series of long iron tubes or pipes fixed in an inclined position and through which the water is made to circulate, whilst the fire and heat by suitable arrangements is compelled to travel amongst them on the outside before reaching the chimney.

Another form of boiler, the vertical or upright steam boiler, is used where economy of space is an absolute consideration. The boiler is formed of an iron cylinder set up on end in which is contained the water and a multitude of tubes through which the fire placed in the centre of the cylinder and its heat is compelled to travel before reaching the chimney. In some of these boilers the water passes through the tubes, and the fire and heat outside them.

Lately, in one and the same vertical boiler, both plans above referred to are adopted. The tubes in these boilers are sometimes placed in a vertical, and sometimes in a horizontal or inclined position.

The application of the power of steam to raise water above its natural level appears to have been known to the ancient Greeks and Egyptians. Plato, the Greek philosopher, born at Athens B.C. 429, and who died 347 B.C., writes: "That "which we now call water becomes as a stone or solid (ice),

" but being melted or diffused by heat it becomes gas or air " (vapour)."

Marine Steam Engines and Boilers.—Propellers.

SCREW ENGINES.

32. MODEL, scale 1½ inches to 1 foot. The Horizontal Condensing SCREW ENGINES of H.M.'s Turret ship "MONARCH." 8,164 tons. Built 1868. 1,100 Horse-power, nominal.

Lent by Messrs. Humphrys and Tennant, Engineers, Deptford. 1869.

Note.—The engines of H.M.S. "Monarch" were designed and built in 1868 by the lenders of the model. The indicated horse-power of them is 6,600 horses. The engines make 60 revolutions per minute and are on the direct-acting principle, with return connecting rods, and have surface condensers. There are four piston rods to each engine piston. The cylinders are 120 inches in diameter, having a stroke of 4 feet 6 inches.

The condensers are of wrought iron, their tops being of cast-brass. They can be used either as surface or jet condensers. They contain 17,264 copper tubes, each 6 feet long, giving large condensing surface per nominal horse-power. The water is driven through the condensers passing outside the tubes, by a reciprocating pump, the inlet and outlet pipes being of ample diameter.

The cylinders of the engines are steam jacketed.

The crank shaft is 22 inches in diameter, and the propeller shaft 18 inches.

The starting, stopping, and reversing gear is placed on a central platform between the cylinders and condensers of the engines.

The crossheads to piston rods are forged solid; their guides have very large surfaces; they are easily adjusted.

The boilers are tubular, having brass tubes. They contain 21,000 square feet of heating surface and about 770 square feet of grate surface.

The ship's propeller is a two-bladed Griffith screw, of gun-metal; 23 feet 6 inches diameter, with adjustable pitch from 23 feet 6 inches to 28 feet 6 inches. The propeller weighs 22 tons.

33. MODEL, scale 1 inch to 1 foot. The Horizontal Condensing SCREW ENGINES of H.M.'s Turret ship "PRINCE ALBERT." 2,529 Tons. Built, 1864. 500 Horse-power, nominal.

Lent by Messrs. Humphrys and Tennant, Engineers, Deptford. 1869.

Note.—The "Prince Albert" was built in 1864 by Messrs. Samuda. She is an armour-plated turret ship 240 ft. in length, 48 feet beam, 25 feet 3 inches in depth. She is driven by engines, of which the model is a representation, and was fitted with a four-bladed screw propeller.

34. MODEL, on a $\frac{1}{10}$ scale. The Horizontal Condensing SCREW ENGINES of H.M.'s ships "NELSON;" built, 1814. Altered for the Screw Propeller, 1860. "CONQUERER," built 1833; altered for the Screw Propeller, 1859; "TAMAR;" built 1863. The Engines are of 500 horse-power, nominal. Diameter of cylinders, 71 inches; stroke, 3 feet.

Lent by Messrs. Ravenhill, Easton, & Co., Engineers, Ratcliff, London. 1869.

See also—Paddle Engines, p. 25.

35. MODEL (WORKING), scale 3 inches to 1 foot. The Condensing VERTICAL SCREW ENGINES of the Steamship "A. LOPEZ." Cadiz and Havannah Spanish Mail Service.

Constructed by Messrs. W. Denny and Brothers, Engineers and Shipbuilders, Dumbarton.

Purchased. 1871.

Note.—The engines are constructed on the hammer or inverted cylinder principle, and have condensers, air and feed pumps, variable expansion gear, &c. The model is a complete working condensing engine of about 15 horse-power. It was made in 1866–7, and exhibited in motion at the Paris Universal Exhibition of 1867.

The Condensers of these engines are on Spencer's Surface plan. They comprise a large central box, on the top edges of which rest the cylinders, inverted. The piston rods, two to each piston, work down by the sides of the condenser, and move in guides carried by the sides of the box. The pumps are worked off the crossheads, which are suitably prolonged for the purpose.

36. SCREW ENGINE. High-pressure Non-condensing SCREW ENGINE. 3 Horse-power; for Screw Steam Launches. Constructed on the hammer or inverted cylinder principle. Diameter of cylinder, 5 inches. Stroke, 6 inches.

A. Verey and Co., Engineers. 1875.

Note.—This launch engine and its screw propeller is exhibited by Mr. Thomas Wilkins, 96, Lyndhurst Road, Peckham.

See also Screw Propeller, page 33.

37. SECTIONAL MODEL; in Wood. SIDE-BY-SIDE CYLINDER HORIZONTAL COMPOUND ENGINES. Designed by John Milner, C.E., 1853.

Lent by Mr. J. Warriner, per Messrs. Maudslay, Sons, and Field, Engineers, Westminster Bridge Road. 1876.

Note.—This sectional model represents one of the earliest proposals for applying the compound, or combined high and low pressure cylinder system, to marine steam engines. At the present time engines with combined high and low pressure cylinders, instead of the old form of equally sized cylinders, are now of constant application in marine engineering. The model has been removed.

38. MODEL, in Wood. The Compound Horizontal SCREW ENGINES of H.M.'s Ships "BOADICEA" and "BACCHANTE." 5,250 Indicated horse-power. Built 1875–76.

Lent by Messrs. J. and G. Rennie, Engineers, Holland Street, Blackfriars. 1876.

Note.—The engines of these ships on the compound system have three cylinders lying side by side; the centre one being high pressure, and the two others low pressure cylinders. The condensers are on the surface system, having independent pumps for water circulation. The engines are direct acting and have all the modern arrangements for their control and economic working.

39. MODEL, in Wood. The Inverted Cylinder COMPOUND ENGINES of the Peninsular and Oriental Company's Screw Steamship "PERA." 2,000 Indicated horse-power. Built 1872.

Lent by Messrs. J. and G. Rennie, Engineers, Holland Street, Blackfriars. 1876.

Note.—These engines are on the upright or vertical system. They are direct acting and have injection condensers.

40. MODEL, in Wood. REVERSED Horizontal Marine SCREW ENGINES. Built 1860.

Lent by Messrs. J. and G. Rennie, Engineers, Holland Street, Blackfriars. 1876.

Note.—In these engines the cylinder and condenser of each engine are set side by side, and lie opposite each other contrarywise, which arrangement necessitates one engine moving in the contrary direction to the other, and hence the name "reversed" engines. Only one or two sets of engines arranged in this manner have been built by the exhibitors. They are constructed on the principle known as the "trunk" system, for the piston and connecting rods of the engines. These engines are fitted with injection condensers.

41. MODEL, in Metal, on a scale of the Compound, Inverted, Surface Condensing SCREW ENGINES of P. and O. Company's Steamer "Carnatic." Constructed and fitted to ship in 1863 by Messrs. Humphrys, Tennant, and Company, London.

Lent by the Peninsular and Oriental Steam Navigation Company, Leadenhall Street, E.C. 1878.

Note.—The screw engines of the "Carnatic" were of 400 nominal horse-power, and 2,500 indicated horse-power. They were fitted with four, two high and two low, pressure cylinders of 43 and 96 inches diameter respectively, and a stroke of three feet. The engines made 72 revolutions per minute on trial. The cylinders are placed one on top of the other. The air pumps are driven by separate piston rods. The condensers are formed in the engine framing.

42. MODEL, in Metal, and Brass; on a scale of 1 inch to 1 foot. The Horizontal SCREW ENGINES of H. M.'s Ships "MINOTAUR" and "NORTHUMBERLAND," 1866. Constructed on Penn's Trunk System. Nominal Horse-power 1,350.

Lent by Sir Tevor Lawrence, Bart., Burford Lodge, Dorking. 1878.

Note.—The model represents a pair of engines having cylinders 100 inches in diameter, and a stroke of 6 feet. The diameter of the trunks is 36 inches. The engines have surface condensers, air and bilge pumps, expansion gear, and link motion for driving and reversing the slide valves for admission of steam to the cylinders. The cranks on the engine shaft are balanced. The real engines and this model of them were constructed by Messrs. John Penn and Son, Engineers, Greenwich.

43. DRAWING, scale 1 inch to 1 foot. The Compound Inverted Cylinder SCREW ENGINES of the Steamships "EDINBURGH CASTLE" and "WINDSOR CASTLE." Built and Engined in 1872 by the Donors of the drawing.

Presented by Messrs. R. Napier and Sons, Engineers, Glasgow. 1874.

Note.—The engines are of 270 horse-power, nominal, having surface condensers, air and feed pumps, link motion, for reversing, &c.

Diameter of high-pressure cylinder, 44 inches.

Diameter of low-pressure cylinder, 72 inches.

Stroke, 3 feet 6 inches.

The steamships belong to Messrs. Donald Currie and Co.'s Colonial Line of Mail Steamers, and run direct between London and the Cape of Good Hope.

44. THREE DRAWINGS. The Inclined Cylinder SCREW ENGINES of H.M.'s "CONSTANCE." Constructed for the ship in 1863 on the Compound principle, by Randolph Elder and Co., Engineers, Glasgow.

Lent by Messrs. John Elder and Co., Glasgow. 1876.

Note.—These engines were the first ever fitted in any of H.M.'s Ships on the compound principle. Each engine has

one high-pressure cylinder 60 inches in diameter; and two low-pressure cylinders 78 inches in diameter. The stroke is 3 feet 3 inches in length. The engines are fitted with surface condensers; air, bilge, and circulating pumps, and other modern arrangements. The drawings represent a plan of the engines, and two elevations of them as fitted in the ship, one looking forward the other looking astern.

45. DRAWING. PAIR of Compound Marine SCREW ENGINES of the Vertical or Upright type. Constructed by John Dickenson, Engineer, Sunderland.

Lent 1876.

Note.—The drawing represents a front elevation and a side view of these engines. They are constructed on the inverted cylinder system, having two cylinders, surface condensers, air circulating and bilge pumps, and other modern arrangements. The engines are of the larger class.

46. DRAWINGS. Compound Surface-condensing MARINE ENGINES.

Lent by Messrs. T. Richardson and Sons, Hartlepool. 1876.

Note.—Three drawings of marine engines of the most modern construction.

One drawing represents engines of the largest class, from 205 horse-power upwards, fitted with steam reversing gear, surface condensers, and other modern arrangements. Designed 1875.

Another drawing represents engines of a more moderate size, and gives the names of the vessels into which they have been fitted. Designed 1871–73.

A third drawing represents marine engines of the smaller class.

The three drawings all represent compound surface-condensing engines, for driving the screw propeller. These engines are all of the inverted cylinder upright or vertical type designed by Mr. Charles Smith.

47. DRAWING. Design for a 60 Horse-power Low-pressure CONDENSING ENGINE, on the DISC System of the late G. Rennie. 1855.

Lent by Messrs. J. and G. Rennie, Engineers, Holland Street, Blackfriars. 1876.

Note.—This form of engine for driving a screw propeller was designed with a view of gaining much economy in space, and of doing away with many of the working parts of the ordinary marine screw engine. In 1853 an engine on the "Disc" system of the late Mr. G. Rennie, (born 1791, died 1866,) was fitted for trial on board H.M.S. "Cruiser," 747 tons. The "Disc" engine is essentially a direct-acting engine. The drawing shows a section of the hull of the "Cruiser" with the emplacement of the disc engine, and an outline in

red ink for comparison of the form and space occupied by the old engines in the vessel. The old engines and the disc engine were of the same nominal power of 60 horses.

48. MODEL. The Inverted Cylinder Upright Compound SCREW ENGINES of the White Star Line Steamship "Britannic," Messrs. Maudslay, Sons, and Field, Engineers, London, 1874.

Lent by the White Star Line Co. (Messrs. Ismay, Imrie, and Co.), 10, Water Street, Liverpool. 1879.

Note.—The White Star line screw steamship "Britannic" was built of iron at Belfast by Messrs. Harland and Wolff, and launched February 1874. She is 480 feet long, 50 feet broad, 35 feet depth of hold, and over 5,000 tons gross burden. Horse-power 760. Speed 16 knots.

The engines designed and constructed for the ship by Messrs. Maudslay, Sons, and Field, are of the vertical cylinder compound type. They comprise four cylinders, the high pressure being directly over the low pressure cylinder.

The engines have surface condensers, circulating pumps, steam starting and stopping gear, together with the most recent appliances and improvements attached to large screw engines. The model represents all the details of the real engines in their entirety. The high pressure cylinders are 48 inches in diameter, low pressure cylinders 83 inches in diameter, stroke 5 feet. The engines make 50 to 55 revolutions per minute. The condensers have 4,762 tubes, 8½ feet long and ¾-inch in diameter, giving an aggregate surface of 9,000 square feet. Centrifugal circulating pumps 5 feet diameter are driven by a pair of engines with 12-inch cylinders and 15-inch stroke. Expansion valves are fitted to the high pressure cylinders, and work on the back of the ordinary slide valves. Steam is supplied by eight oval boilers 8 feet 10 inches wide, 14 feet 4 inches high, and 19 feet 10 inches long. The boilers are fired at both ends, and have each four furnaces, making 32 in all, with a grate area of 680 square feet. The boilers contain 2,432 tubes 7 feet 2 inches long, 3½ inches diameter, giving total heating surface of 15,900 square feet. The engines develope 5,000 indicated horse power.

49. MODEL in Wood. CRANK MOTION for Inverted Screw Engines, designed by Exhibitor, 1855.

Lent by Mr. T. F. Chappé, C.E., 29, Stanley Gardens, Notting Hill. 1879.

Note.—This model is a sectional model, showing a pair of steam cylinders obliquely inverted, with piston, piston rod, and connecting rod, driving through a link motion one crank on the shaft. The motion contemplated avoiding the engines hanging on the centre or dead-point of revolution, and they were arranged for gun-boats of shallow draught, so as to bring the machinery below the boat's water line.

Paddle Engines.

50. Model, on a scale of 1½ inches to 1 foot. The Oscillating Cylinder Paddle-wheel Condensing Engines of the Holyhead and Kingstown Royal Irish Mail Steamer "Leinster." 750 Horse-power, nominal. Diameter of cylinders, 98 inches; stroke, 6 feet 6 inches.

To the engines are attached, on the same scale, The Feathering Float Paddle-Wheels of the ship; which are 32 feet in diameter. The floats are 12 feet long by 4 feet 10 inches deep.

Lent by Messrs. Ravenhill, Easton, and Co., Engineers, Ratcliff, London. 1869.

Note.—The length of the "Leinster" is 350 feet over all. Beam, 35 feet; depth of hold, 21 feet. Tons, 2,000. The ship has 8 boilers, 4 fore and 4 aft the engines, having 40 furnaces fired in line with the keel. The draught of the ship is 8 feet 6 inches on an even keel, and her speed about 21 statute miles per hour. She was built by Messrs. Samuda Brothers, Poplar, in 1860.

50A. Model of the Engines of the Paddle-wheel Steamer "Helen McGregor," of Liverpool.

Designed and arranged in 1843 by G. Forrester and Co., Engineers.

Lent by Messrs. G. Forrester and Co., Liverpool. 1869.

Note. — This engine has two inverted steam cylinders driving one crank on paddle shaft, with a very long stroke. It occupies very little hull space. The engine is a condensing low-pressure engine and is said to have been still at work in 1873.

50B. Model of a Paddle Marine Engine. Designed by J. Scott Russell, F.R.S.; having three Oscillating Cylinders all connected to one Crank on the Paddle Shaft. One of the cylinders is vertical, the other two are inclined inwards at about 45°.

Lent by Mr. J. Scott Russell, F.R.S. 1869.

The model made by Jabez James, Lambeth.

51. The Original Marine Steam Engine. Made for Patrick Miller, Esq., by William Symington, Engineer, 1787: and used by him in a boat on the lake at Dalswinton, N.B., 1788.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—For some years prior to 1787 Patrick Miller, Esq., of Dalswinton, Scotland, had been engaged in a series of experiments with double and triple vessels propelled by paddle-wheels, worked by manual labour. In the experimental

trips of 1786 and 1787, he was assisted by Mr. James Taylor (the tutor to his younger sons), and at the suggestion of Mr. Taylor it was determined to substitute steam power for manual labour. For this purpose, in the early part of 1788, Taylor introduced William Symington, an engineer at Wanlockhead Lead Mines, who had previously obtained letters patent (June 5, 1787, No. 1,610) for "his new invented steam engine on principles 'entirely new.'"

An arrangement was made with Symington to apply an engine, constructed according to his invention, to one of Mr. Miller's vessels, and consequently the engine which forms the subject of this notice was made, the castings being executed in brass by George Watt, founder, of Low Calton, Edinburgh, in 1788. At the beginning of October in that year the engine, mounted in a frame, was placed upon the deck of a double pleasure boat, 25 feet long by 7 feet, and connected with two paddle-wheels, one forward and the other abaft the engine, in the space between the two hulls of the double boat. On the steam-engine being put in action it propelled the vessel along Dalswinton Lake at the rate of 5 miles an hour.

52. WATER-COLOUR DRAWING. The Oscillating Cylinder ENGINES. Fore and Aft Sets of BOILERS; and The Feathering Float Paddle-Wheels of the Sydney and Melbourne Royal Mail Steamship "PACIFIC." 500 horse-power, nominal. These Engines, Boilers, and Paddle-wheels, together with the ship, were designed and built by Mr. John Scott Russell, F.R.S., about 1854. Scale, ½ inch to 1 foot.

Lent by Mr. John Scott Russell, F.R.S. 1868.

Note.—This Drawing shows side elevation of the engines and paddle-wheels. A front elevation of the boilers, which are placed parallel to the keel line. Also a plan of the engines, and fore and aft sets of boilers.

The boilers are separated from the cargo space and engine room, by wrought-iron water-tight bulkheads.

53. WATER-COLOUR DRAWING. Longitudinal Through Section of the "GREAT EASTERN" Steamship. Showing Details and Arrangements of the PADDLE-WHEEL AND SCREW-PROPELLER ENGINES; Fore and Aft Sets of BOILERS; and other Steam Machinery of the ship. Scale, ⅛ inch to 1 foot.

Lent by Mr. John Scott Russell, F.R.S. 1868.

Note.—The "Great Eastern" steamship (originally called the "Leviathan") was designed by the celebrated engineer I. K. Brunel about 1852. He was born in 1806 and died in 1859. His father, Sir Isambard Brunel, the engineer of the Thames Tunnel, begun 1825, opened 1843; the Great Western Railway broad-guage system, 1839–1841, and

many other large works, was born in Normandy in 1769, and died in 1849, in England.

The "Great Eastern" was built of iron by Messrs J. Scott Russell and Company in 1857. She was laid down and launched broadside into the Thames at their shipbuilding establishment at Millwall.

The drawing represents a longitudinal through section of the ship, showing the emplacement of the engines for driving the paddle-wheels and screw propeller, the ships' boilers, coal bunkers, and other machinery detail.

The paddle-engines are 1,000 horse-power nominal, the screw engines are of 1,700 horse-power nominal.

The former were designed and constructed by Mr. J. Scott Russell. They consist of two distinct engines having a pair of oscillating inclined cylinders of 74 inches in diameter and a stroke of 14 feet, separate air pumps, condensers, etc, complete. These engines drive paddle-wheels 56 feet in diameter.

The screw engines were constructed by Messrs. James Watt and Co., Birmingham. They are of the horizontal type having four cylinders, each 84 inches in diameter, with a stroke of four feet. A pair of cylinders lying opposite to each other drive through connecting rods the main and screw shaft. The screw is 24 feet in diameter and 44 feet pitch. It weighs 36 tons. The boilers, 10 in number, supplied steam at 15 lbs. to 25 lbs. pressure per square inch to the paddle and screw engines.

NOTE ON MARINE STEAM ENGINES.

It may be useful to give here in connection with the Models and Drawings of Marine Engines, a short list of the various kinds of engines used for marine purposes, their technical names and principal constructors.

1. *Paddle Wheel Engines.*

Side lever engines - - -	Engineers of London, the Clyde, and others.
Vertical engines - - -	Engineers of London, Liverpool, &c.
Steeple engines - - -	Engineers on the Clyde chiefly.
Inclined cylinder engines -	Engineers of England and Scotland.
Oscillating or vibrating cylinder engines - - - -	Engineers of London, the Clyde, Belfast, and many others.
Half beam engines usually fitted in paddle-wheel tug boats.	Engineers of London, Liverpool, the Clyde, Belfast, and all seaport towns.

All these engines for driving páddle-wheels are however now very nearly obsolete, except in the case of oscillating cylinder engines (brought out in 1827 by Mr. Joseph Maudslay), and still used for high-speed steam vessels; and the half beam engines fitted in paddle-wheel Tugs. The rocking-beam engines of America, fitted in "side-wheel" steamers, may be noted as an original and peculiar form of paddle-engine.

Screw Engines.

Inclined cylinder engines. Inverted cylinder engines on the simple and compound systems. Used for steamships of the merchant world.	Engineers throughout England, Scotland, and Ireland. They are simply universal.
Horizontal cylinder engines on the simple and compound systems. Used chiefly for ships of war.	Engineers of England and Scotland chiefly.

Some war ships have been fitted with screw engines having cylinders inclined inwards and working inwards; others again have had fitted to them vertical or upright engines with inverted cylinders, and working direct downwards. The principle forms of screw engine adopted for ships of war, however, are those in which the cylinders lie on their sides horizontally, and drive their crank-shafts, which lie parallel to or along ships' keel line, by direct action or connecting-rod motion with the crank-shaft.

Marine Steam Boilers.

54. Model, in Wood. Made in parts to take to pieces, and show Interior Disposition. Marine Multi-flue Steam Boiler. Hawthorn's Patent 1868. Designed for High-pressure working, with several new and special features. The boiler is arranged with High Level Furnaces; Interior Water Tubes, and High Steam Room.

Lent by Messrs. R. & W. Hawthorn, Engineers, Newcastle. 1869.

Note.—A set, consisting of two of these steam boilers, was fitted to the Iron Screw Steamship "Mercury;" 120 horse-power, in 1869. Each boiler was 11 feet long, 9 feet wide, and 11 feet 3 inches high. The boilers having two furnaces each, 2 feet 6 inches wide, 3 feet 6 inches high, with grate bars 5 feet long.

In each boiler are three flues, respectively 2 feet 6 inches wide by 3 feet 6 inches high; 2 feet 6 inches diameter;

1·92 feet diameter; and leading into a dry uptake in front of boiler.

The flues and flame chambers are strengthened by water tubes 8 inches in diameter, which increase the heating surface and promote the water circulation.

The furnaces are placed in the centre of the boilers, the water level being 8 inches above their crowns. The flues lead downwards, the last series being close to the bottom of the boilers.

The total internal heating surface in both boilers is 1,320 square feet. The grate bar surface 42·2 square feet. The working pressure of steam 45 lbs. per square inch.

The weight of the boilers, without mountings, 25½ tons. Filled for work, the weight of water is 17¾ tons.

55. DRAWING, Coloured. A Patented MULTI-FLUE MARINE BOILER for High pressure; by Messrs. R. & W. Hawthorn, 1868. Scale, ½ inch to 1 foot.

Lent by Messrs. R. & W. Hawthorn, Engineers, Newcastle-on-Tyne. 1869.

Note.—The drawing shows a front view and cross section of the boiler. Longitudinal through sections and cross sections. A sectional plan.

56. MODEL of a Set of Patent High-pressure Marine Tubular STEAM BOILERS. Designed for the continuous use of Fresh water.

Lent by Mr. William Gray, Dawlish. 1874.

Note.—These boilers possess the following arrangements:— They are fired from each end, the furnaces having special air flues designed to assist in the combustion and the consumption of smoke. They are multi-tube boilers, having steam superheaters and over-all large tanks to contain fresh water, which supply the boilers with heated feed water. The working pressure is 100 lbs. per square inch.

57. DRAWING. SECTIONS of Gray's Patent High-pressure Marine STEAM BOILERS, showing arrangement of the Tubes, Steam Superheater; Water heater, and Flues. Scale, ½ inch to 1 foot.

Lent by Mr. W. Gray, Dawlish. 1874.

58. DRAWING, on a ¾ inch to 1 foot Scale. Improved Marine Water-tube STEAM BOILER. For High pressure.

Designed and patented by Messrs. J. and F. Howard. Made by the Barrow Shipbuilding Co., Barrow-in-Furness.

Lent by Messrs. J. and F. Howard, Engineers, Bedford. 1874.

Note.—The drawing shows a front view of the boiler, side elevation, longitudinal through section; and a section through

tube plates showing method of coning joints, on a quarter full-size scale. See page 15.

59. DRAWING of Messenger's Patent High-pressure Vertical Water-tube BOILER. For Steam Yachts and Launches. Designed by Mr. Thomas Messenger about 1869.

Messrs. A. Verey and Co., Engineers. 1875.

60. DRAWING, Showing Part Elevation, Section and Plan, of the TUBULAR BOILERS of the Paddle-wheel steam yacht "GALATEA." 200 nominal horse-power. Belonging to the Trinity House Corporation.

Lent by W. Willis. 1876.

Note.—The boilers of the "Galatea," as well as the ship and her engines, were constructed by Messrs. Caird and Co., Greenock, in 1867. They have a heating surface of 5,308 square feet. The fire-grate surface 186 square feet. Water space 1,592 cubic feet. Steam space 752 cubic feet. The drawing is on a scale of 1 inch to 1 foot, and is photographed and printed from the original, by Willis' Patent Aniline Process.

61. ILLUSTRATIONS (full size). The CONNECTIONS for the WATER-TUBES of Marine Steam Water-Tube Boilers.

Lent by Mr. J. F. Flannery, 6, Broadway Chambers, Westminster. 1876.

Note.—The water tube connections exhibited (on the systems known as Root's Patent, Howard's Patent, and the ordinary form), for the joints of the tubes of this class of marine boiler are full working size, and show the means employed for securing efficient circulation of the water throughout the tubes.

62. DRAWINGS. MARINE STEAM BOILERS. For Lecture purposes. By Mr. J. F. Flannery, 9, Fenchurch Street, E.C.

Lent 1876.

Note.—These drawings relate exclusively to boilers for steamships, known as "water-tube boilers." They represent the systems of Messrs. Howard, Root, and Wigzell, for these boilers; and in various forms (as shown by the drawings), they have been fitted and worked in the steamships "Birkenhead," "Montana," "Propontis," and steam flat "Gertrude," all of Liverpool. Figure 1 of these drawings represents a water-tube boiler of the ordinary type.

63. DIAGRAMS. Coloured Drawings for lecture purposes. MARINE Steam Water-tube BOILERS.

1. Rowan's Boiler, with forced combustion arrangements. (in two sheets).
2. Boiler of s.s. "Belleville."

3. Watt's Boiler. (In two sheets.)
4. Howard's Boiler.
5. Furnace for Marine Boiler.

Lent by Mr. F. J. Rowan, C.E., 5, Westminster Chambers, Victoria Street, S.W. 1878.

64. WATER-COLOUR DRAWING. Midship section of the "GREAT EASTERN" Steamship. Showing Construction and Emplacement of the BOILERS; Feed Pumps, and Steam Pipes. Scale, ¼ inch to 1 foot. See also page 26.

Lent by Mr. John Scott Russell, F.R.S. 1868.

65. PHOTOGRAPH of a TWIN SCREW Vertical Steam Engine; and UPRIGHT BOILER. — For Steam Yachts, Launches, &c.

Presented by Messrs. A. Chaplin & Co., Glasgow.

66. PHOTOGRAPH of a Double Cylinder SCREW ENGINE, for a Single Screw Propeller; with Horizontal Steam Tubular BOILER.

Presented by Messrs. A. Chaplin & Co., Glasgow.

67. PHOTOGRAPH of a DOUBLE CYLINDER Paddle-boat ENGINE; with Vertical Steam BOILER. See also pages 59, 146, 150.

Presented by Messrs. Alexander Chaplin & Co., Engineers, Glasgow. 1874.

68. MODELS. Illustrating Samson Fox's Patent CORRUGATED Iron BOILER TUBES for Flues, and their application to land and marine steam boilers.

Lent by Mr. Samson Fox, Leeds Forge, Wortley, Leeds. 1879.

Note.—These corrugated iron tubes or flues for steam boilers, together with powerful rolling mills for corrugating the plates for them, were designed and carried out 1876–7 by Mr. Samson Fox of the Leeds Forge Company, New Wortley. The corrugated tubes have been tested to the severe pressure of 1,000 lbs. per square inch.

69. SECTIONAL MODEL. Model in copper of a MULTITUBULAR MARINE STEAM BOILER, with Samson Fox's Patent Corrugated Furnace Flues, and Hepburn's Patent Shell Expansion Ring.

Lent by Mr. Samson Fox, Leeds Forge, Wortley, Leeds. 1879.

70. WORKING MODEL of Mr. Samson Fox's Patent Rolling Mill for corrugating on his system the iron plates for boiler furnaces and fire flues.

Lent by Mr. Samson Fox, Leeds Forge, Wortley, Leeds. 1879.

Note.—This working model of Mr. Samson Fox's Rolling Mill for corrugating rolled iron plates for boiler flues represents a heavy machine set up at the Leeds Forge Company's Works. To describe the special arrangements in these iron corrugating machines for boiler flues would occupy too much space here; suffice, however, to say that the model shows the general principles and details of the corrugating mill.

NOTE ON MARINE BOILERS.

At the present time two descriptions of boilers for marine purposes are in general use.

1. The multitubular boiler, in the interior of which are arranged a quantity of small tubes fixed in a horizontal direction through which the products of combustion from the fires are made to pass before reaching the up-take or chimney, whilst the water in the boiler surrounds them in mass. These boilers have several furnaces to each boiler which are arranged to be fired sometimes at one end of the boiler only, sometimes at both ends, and sometimes laterally, according as the available space on ship-board will best allow.

2. Water-tube boilers, in which iron tubes or pipes are fixed in an inclined or other position and through them the water in the boiler circulates. The heat and products of combustion of the furnaces in these boilers are made to travel completely amongst and round the water-tubes, before reaching the up-take or chimney, by an arrangement in some cases of iron plates fixed amongst them, known as "Baffle-plates," or by the arrangement and disposition of the water-tubes themselves.

PROPELLERS.

71. MODEL of a Double Boat fitted with a SCREW PROPELLER forward, to be driven by manual power. Tried in the Sussex river Ouse, 1823. The boat only attained a small rate of speed.

Lent by Mr. Burwood Godlee. 1872.

72. MODEL (unfinished) of a Ship, with a peculiarly made SCREW PROPELLER; having three fans or blades, and showing method for securing the screw blades in their proper and relative positions. 1846.

1864.

73. Model, No. 1. A Self-feathering Screw Propeller. Adapted for auxiliary and small screw vessels.

Designed to obviate the necessity of raising the screw when under sail.

Proposed by the Inventor, Rev. P. A. Fothergill, Hocksley, Chelmsford.

Lent 1871.

73a. Model, No. 2. Fothergill's Self-feathering Screw Propeller. Adapted for auxiliary and small screw vessels. Designed to obviate the necessity of raising the screw when under sail. The screw is entirely self-acting and requires no internal gearing. It can be set to any pitch, and used with any number of blades.

Lent by Inventor, Rev. P. A. Fothergill, Hocksley, Chelmsford. 1871.

74. Model (full size) of a Screw Propeller. Patented by Dr. J. Collis Browne, late Army Medical Staff.

Note.—The propeller is said to possess the following features:—

a. Absence of vibration.

b. Reduction of wear and tear in the driving machinery.

c. Adaptability to any screw steamship.

d. Facility for checking ship's way; and for going full speed astern or ahead with increased speed and celerity.

e. Direct action of the water on the axial line of screw.

f. Affording increased steering power.

Note.—The steam screw river yacht "Lapwing," eight horse-power, owner Dr. J. Collis Browne, is fitted with this screw.

Lent by Dr. J. Collis Browne, 34, Leadenhall Street, E.C. 1874.

75. Screw Propeller. Three-bladed Screw Propeller for Steam Launches. Diameter, 22 inches. Pitch, 2 feet 6 inches.

Lent by the Makers, Messrs. A. Verey & Co., Engineers. See also Screw Engine and Boiler, page 20. 1875

76. Model, in Gun Metal. A Screw Propeller on the late Mr. James Lowe's principle for the blades. 1838.

Presented by Mrs. Henrietta Vansittart. 1874.

76a. Whole Model of Steamboat "James Lowe," fitted in 1838 with a Screw Propeller, under a Patent granted to late Mr. James Lowe, in March 1838, for Submerged Propellers.

Note.—About the same time a large boat called the "Wizard" was fitted with a Screw or Submerged Propeller, under the late Mr. J. Lowe's patent.

Presented by Mrs. Henrietta Vansittart. 1874.

76*b*. MODEL of the Stern of a Ship, fitted in March 1838 with a SCREW PROPELLER, having One or more Curved blades; Sections or portions of a Screw, of uniform or increasing pitch. Placed below the water-line of the ship.

Designed by the late Mr. James Lowe, 1838.

Presented by Mrs. Henrietta Vansittart. 1874.

77. WHOLE MODEL of the Steamship "Great Britain," fitted on the late Mr. James Lowe's plan for submerged or SCREW PROPELLERS.

Presented by Mrs. Henrietta Vansittart. 1874.

78. MODEL, in Wood, of the FIRST SHAFT AND BOSS made for Screw Propellers, by late Mr. James Lowe, 1838.

Presented by Mrs. Henrietta Vansittart. 1874.

79. MODEL, in Wood, of the FIRST SPHERICAL BOSS for Screw Propellers, made by Mr. James Lowe, 1852.

Presented by Mrs. Henrietta Vansittart. 1874.

80. MODEL, in Wood, of the FIRST OVAL BOSS for Screw Propellers, made by Mr. James Lowe, 1855.

Presented by Mrs. Henrietta Vansittart. 1874.

81. MODEL, in Wood, ¼ full size. The "Lowe-Vansittart" SCREW PROPELLER BLADES.

Designed and fitted in 1869, by Mrs. Henrietta Vansittart, for trial on board H.M.S. "Druid," 350 horse-power.

Presented by Mrs. Henrietta Vansittart. 1874.

82. THREE MODELS, showing the Original Design of the After Bodies of the First SCREW STEAMERS "ARCHIMEDES," built 1839; and "NOVELTY," built 1839–40.

The models show the Forms of the original Submerged SCREW PROPELLERS as fitted to the two ships, and modifications. The "Novelty" ultimately was driven by direct-acting engines, and two-bladed screw.

Lent by Mr. H. Wimshurst, Anerley. 1873.

Note.—The dimensions of the ship "Archimedes" were,—extreme length 125 feet, extreme breadth 22 feet 6 inches, depth 13 feet, tons 240. The engines were of 80 horse-power, nominal. The diameter of the screw 6 feet 9 inches length of screw 5 feet. It was driven by vertical engines and multiplied wheel gearing.

83. WORKING MODEL, in Brass. Griffiths' PATENT SCREW PROPELLER.

Lent by Mr. R. Griffiths, 43, Westmoreland Road, Bayswater. 1875.

Note.—This model represents a Two-blade Griffiths' Screw Propeller with central boss, and has screw gearing attached to it by which the pitch of the blades can be altered at pleasure from in-board.

84. MODEL, in Brass, of the SCREW PROPELLER designed by the late Mr. G. Rennie, about 1840.

Lent by Messrs. J. and G. Rennie, Engineers, Holland Street, Blackfriars. 1876.

Note.—This screw was tried in 1843 in H.M.S. "Dwarf," and drove the vessel at a speed of 12 miles per hour. The "Dwarf" was built of iron, and was the first screw steamship belonging to Her Majesty's Navy. She was originally called the "Mermaid."

85. DRAWING. The original SCREW PROPELLER; designed by the late Mr. G. Rennie, about 1843, and tried in H.M.S. iron ship "DWARF."

Lent by Messrs. J. and G. Rennie, Engineers, Holland Street, Blackfriars. 1876.

86. THREE MODELS, in Wood; showing the forms from which the Blades of SCREW PROPELLERS are obtained.

Lent by Mr. Woodcroft, F.R.S. 1876.

Model A is a disc projecting from a shaft. If the blade or white portion on the disc (a sector deprived of the part nearest the apex or point where the two radial sides meet) be cut from the disc, and placed at an angle upon a shaft or axis, an inclined plane propeller is produced.

Model B is a uniform pitch screw, the white part or blade cut from this screw and fixed on a shaft is the ordinary screw propeller.

Model C. By cutting the white portion of this model, and placing it on a shaft, the increasing pitch propeller is obtained.

87. MODEL, in Wood. An Increasing Pitch SCREW PROPELLER. Designed by Mr. Bennet Woodcroft 1832–1846.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—The peculiar form of this propeller may be explained as follows:—

A spiral worm or screw is coiled round a shaft or cylinder in such form that the angle of inclination which the worm makes with the axis of the cylinder continually decreases, and the pitch or distance between the coils or revolutions of the spiral continually increases throughout the entire length of the shaft or cylinder upon which the

spiral is formed. By thus progressively elongating the pitch of the screw, each successive part of it in its revolution begins to act before it is overtaken by the current given to the water by the preceding part of the screw, and consequently every part meets resistance from the water and thereby gains propelling power.

88. Model, in Wood; Patent Feathering Screw Propeller. Two Blades. Designed by Mr. B. Woodcroft about 1844.

Lent by Mr. B. Woodcroft, F.R.S. 1877.

Note.—This little model shows an early proposal, about 1844, by Mr. Woodcroft for feathering or varying at pleasure the angle of the blades of the screw propeller in relation to their shaft or axis, by means of mechanical arrangements for the purpose.

89. Models, in Wood; Showing various Curves of Screws for Propellers.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—These are two models representing various forms of curves and variable form of screws. One of the models shows three screws of various curves. The other shows four screws of increasing pitch geared together, by which means the forms of the curves in relation to each other when the screw revolves are clearly discernible and produce a remarkable effect.

90. Model. To show Difference of Inclination in Screw Threads of the same Pitch; traced on cylinders of different diameters.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—In this model the three wooden cylinders or rollers are covered with paper, and the screw threads are shown by blue lines traced on the paper around the rollers.

Two of the rollers are geared together to move at uniform speed, whilst the top roller revolves merely by the friction of the under ones when in action.

91. Three Models; Sterns of Vessels fitted with Varying Pitch Screw Propellers. Woodcroft's Patents, 1832, 1838, 1844, 1846.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—With one of these models is exhibited a single blade of the screw propeller, showing its isolated form. The three models together show the sterns of vessels fitted with Varying Pitch Screw Propellers, the peculiarities of which are detailed in the notes to the three following items.

92. Model. A Varying Pitch Screw Propeller, 1844, on Shaft, in Brass. (Fitted to the stern of a vessel).

Lent by Mr. B. Woodcroft, F.R.S, 1876.

Note.—The first Varying Pitch Screw Propeller ever made was designed and patented by Mr. B. Woodcroft in 1844. In this description of screw propeller the blades, instead of being fixed to the shaft, are moveable, and are combined with suitable apparatus, whereby the angle which the blades form with their shaft or axis can be altered from a less to a greater or greater to a less degree, in order to obtain the best pitch for driving a vessel under varying circumstances.

In 1845 a Varying Pitch Screw Propeller was submitted to the Admiralty, and in 1846 a full-size screw was made of gun metal by Sir Joseph Whitworth, Manchester, for H.M.S. "Dwarf." The screw was 5 feet 8 inches in diameter, and the angle which the two blades of it will form with the shaft may be altered so as to give a variable pitch ranging from 4¾ feet to 10¾ feet.

93. MODEL. A Varying Pitch SCREW PROPELLER in Brass, on Shaft; 1844. (Fitted to the stern of a vessel).

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—The blades of this Screw Propeller (two in number) are cut with an increasing pitch. Screw propellers having blades of uniform pitch are constructed on plans for varying the angle at pleasure which the blades form with their axis or shaft. Hence a screw propeller whose blades are cut on any form of pitch, if they can be altered at pleasure to form different angles with their axis, are called "Varying Pitch Screw Propellers." This capacity for varying the pitch is in practice found useful for ship propulsion under the varying circumstances of long voyages or continuous cruising.

94. MODEL. Varying Pitch SCREW PROPELLER, in Brass. Designed and Patented by Mr. Bennet Woodcroft. 1844. (Fitted to the stern of a vessel.)

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—This Propeller has four blades instead of two, and the apparatus for turning the blades in order to change the angle or pitch is combined with an indicator which shows the angle at which the blades are set in relation to their axis or shaft. In Ocean-going Screw Steamships the blades of a Varying Pitch Screw are usually capable of being turned, and set in such a manner that their edges will stand nearly parallel to the centre line of the propeller shaft, or their faces will be almost in line with ship's keel or run, and so offer little resistance to the vessel's way through the water when she is proceeding under sail only.

95. MODEL, of a Ship. Constructed by Mr. B. Woodcroft for Experiments in Propulsion with PADDLE-WHEELS and SCREW PROPELLERS. 1832–1846.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—This model was constructed by Mr. B. Woodcroft for researches in the relative value of propulsion of ships by paddle-wheels and screw propellers, under uniform and varying circumstances.

96. MODEL, in Wood. A DOUBLE SCREW PROPELLER. Designed and patented by the late Sir Francis Pettit Smith in 1836.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—See next item.

97. MODEL. The After Part of a Vessel fitted with a SCREW PROPELLER. Designed by the late Sir Francis Pettit Smith. 1836.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—The propeller consists of two whole turns of a screw thread round its shaft, and is placed in the dead wood or run of the vessel, but by a memorandum of alteration the patentee limits himself to a screw of one turn or two half turns.

98. SKELETON MODEL. The After Part of a Vessel fitted with a SCREW PROPELLER. Charles Commerow's Patent, 1828.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—This idea for a screw propeller was communicated from abroad to Charles Commerow who took out a patent in 1828. The original drawings of this invention show this screw propeller as applied at the bow and stern of several vessels, and also as placed between two boats fastened together. The propeller represented by the model consists of one whole turn of a screw.

99. MODEL of a PROPELLER for Ships.

Lent by Mr. S. F. Pichler, 162, Great Portland Street, London. 1876.

Note.—The Model represents a Propeller designed to have a motion similar to that of an oar when used in sculling at the stern of a boat.

100. DIAGRAM, of the Original Designs for Submerged PROPELLERS and their BLADES, "Lowe's Steamship PROPELLERS." Patented 24th March 1838 by Mr. James Lowe. This diagram shows various proposals for the forms of blades of screw propellers.

Presented by Mrs. Henrietta Vansittart. 1874.

101. DIAGRAM, illustrating Mr. James Lowe's proposals in 1855, for Dividing the Blades of SCREW PROPELLERS, and placing them in pairs or sets, diagonally across the Screw Boss. Tried on board H.M.S. "Bullfinch," in 1857.

Presented by Mrs. Henrietta Vansittart. 1874.

102. DIAGRAM of Mr. J. Lowe's fourth improvement in SCREW PROPELLERS. 1862.

Presented by Mrs. Henrietta Vansittart. 1874.

Note.—This alteration consists in causing the blades of the Screw Propeller to form a curved line curling in opposite directions from the centre of the back and leading side of the blade to the edges. The drawing also shows the method of fixing the blades to the screw boss. This propeller was further improved by Mrs. H. Vansittart in 1868.

103. DIAGRAM of the Modifications proposed in the "Wyche-Lowe" SCREW PROPELLER BLADES.

Designed in 1852 by the late Mr. James Lowe, and tried on board the S.S. "Miskin" and "Argus." Also the "Lowe-Harris" Screw Propeller. 1862.

Presented by Mrs. Henrietta Vansittart. 1874.

104. DIAGRAM of a SCREW PROPELLER and its BLADES.

Designed by Mrs. Henrietta Vansittart in 1868. Tried on board the "Allan" line S.S. "Scandanavian," 400 horse-power, in 1873; and H.M.S. "Cadmus," 21 guns, 400 horse-power, in 1869, known as the "Lowe-Vansittart" Screw Propeller.

Presented by Mrs. Henrietta Vansittart. 1874.

Note.—The Lowe-Vansittart Propeller on trial on board H.M.S. "Druid" in 1869 has been found to possess, it is stated, full backing power, a total absence of vibration and to give an increased speed upon a reduced consumption of fuel. The propeller has considerable power in stopping ship's way, and affords great facilities for steerage.

The Lowe-Vansittart Propeller has been fitted to many Ocean-going Steamships belonging to most of the principal Steam Navigation Companies of the country, as well as to several of H.M.'s Ships of the Royal Navy.

104 A. MODEL, illustrating Mr. J. J. Kunstädter's SCREW RUDDER for steering steamships. The Steering Screw is attached to and driven by the main screw shaft of the steamship by means of a universal joint, also the exhibitor's invention.

Lent by Mr. J. J. Kunstädter, C.E., 37, Walbrook, E.C. 1879.

Note.—The steering screw when fitted as supplementary to the true propeller of the ship, is found to give the best results, if about $\frac{7}{10}$ths of the screw's diameter are of coarser pitch.

104 B. MODEL, in Brass. Mr. J. J. Kunstädter's Patent Universal JOINT for the transmission of power.

Lent by Mr. J. J. Kunstädter, C.E., 37, Walbrook, E.C. 1879.

104c. Varying Pitch SCREW PROPELLER. Full-size. Original design by the late Bennet Woodcroft, 1844.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—The object realised in this invention is that through suitable arrangements attached to the screw boss, the angle which the blades of the screw form with their shaft or axis can be altered from less to greater or from greater to less, in order to obtain the best pitch for driving a ship under varying circumstances.

104d. MODEL. Bevis's Patent Feathering Screw PROPELLER.

Lent by Messrs. Laird Brothers, Engineers and Shipbuilders, Birkenhead, 1876. 1879.

Note.—Mr. R. R. Bevis, managing engineer to the firm of Messrs. Laird Brothers, of Birkenhead, in 1868 patented an arrangement for altering the pitch or feathering the blades of a screw propeller in a fore and aft direction, which claims to be a great advantage for screw steamers, making them faster and more handy when under sail alone, and when under steam and sail allowing of adjusting the pitch to obtain the best result. A screw propeller of the ordinary kind, whether fixed or revolving, is a heavy drag against speed and handiness for sailing, and "lifting" it is a laborious operation, and requires a large hole or well through the ship's counter to admit of so doing.

The arrangement of this new screw propeller is free from many of the objections which have been made to feathering screws previously tried. The gear for feathering the blades is well protected, the levers and other gear that move the blades being enclosed within the boss of the screw propeller, and attached to a rod passing through the centre of the shaft, which is worked in the screw-shaft tunnel. The operation of altering the pitch, or of feathering the blades to any angle, is done in a few minutes, without in any way putting the engines into such a position that they may not be used in an emergency.

104e. SCREW PROPELLER. Model in metal. ¼ full size. Three-blade Screw Propeller, used for driving swift torpedo steamboats and steam launches.

Lent by Messrs. J. and G. Rennie, Engineers, Holland Street, Blackfriars, S.E. 1879.

Note.—The screw represented by the model is 5 feet 4 inches in diameter, and has a pitch of 6 feet. *See also page* 35.

104f. SCREW PROPELLER. The Mallory Propeller Model, in Wood, on about ¼ scale.

Lent by The Mallory Propeller Co., Limited, 6, Westminster Chambers, S.W. P. F. Nursey, Secretary. 1879.

Note.—The Mallory propeller, the invention of Colonel Mallory of the United States Army of America, was introduced into England in 1878. Its features are that the screw is driven by vertical or upright gear working in a fish-shaped casing. The casing and its driving gear are capable of rotation on a vertical axis. The screw drives the vessel, whilst rotation round its vertical axis converts the propeller at same time into a rudder, and steers the vessel. As the propeller can be rotated a complete circle, the vessel is driven ahead, a-stern, sideways even, stopped, started, or turned about with great rapidity.

104*g*. MODEL. Working Model of King's Patent SHAFT-COUPLING. For securing and temporarily working broken shafts of steamships. J. M. and T. D. M. King, Patentees, 1874.

Lent by Messrs. J. M. and T. D. M. King, 5, Moscow Terrace, Victoria Park, E. 1879.

Note.—This model illustrates clearly the principles of the construction and arrangement of this coupling for the temporary repair at sea of broken propeller shafts of steamships. The coupling is made in four parts, two of which are placed round each end of the broken portion of the shaft, and are firmly bolted together by nuts and bolts. They form two butts, which have their face recessed out sufficiently to admit the original butts of the shaft. The temporary coupling, when securely bolted together round the shaft breakage, is brought together and bolted by bolts and nuts through its own butts. The coupling is keyed up tight on the shaft by keys hollowed on their under side, and held fast in place by binding or pinching screws, which avoids the necessity of cutting key-ways.

PADDLE WHEELS.

105. MODEL of a PADDLE-WHEEL with Improved Floats. Designed about 1850.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

106. MODELS. The Feathering Float PADDLE-WHEELS of the Mail Steamer "LEINSTER." Built 1860. Kingstown and Holyhead Mail Service. Scale 1½ inches to 1 foot.

Messrs. Ravenhill, Easton, and Co., Engineers, Ratcliff, London.

Note.—These paddle-wheels are attached to a model of the engines which drive them. See Page 25.

NOTE ON PROPELLERS.

Propellers used for driving ships are known as paddle-wheel and screw propellers.

Paddle-wheels driven by steam power for the propulsion of ships are of early date. In 1737, Jonathan Hull, an English engineer, designed a steamboat driven by paddles. Since this date innumerable improvements have been made in paddle-wheels, and they are now divided into two sorts.

The "Paddle-wheel," in which the floats or dash-boards on the circumference of the wheel are rigidly fixed to its spokes or arms and periphery.

The "Feathering-float wheel," in which the floats or dash-boards of the wheel are movable, and controlled as to their effective action on the water by means of long rods attached to them, which are governed by an arrangement of a wheel revolving on an axle fixed out of the true centre of the paddle-wheel itself, called the eccentric wheel. The arrangements cause the floats to enter and leave the water almost in a vertical direction edgewise, whilst at its deepest immersion the float is absolutely vertical. These feathering-wheels were first brought out by John Morgan, 1812. Mr. Seaward improved them in 1825 to 1841. Mr. Maudslay again improved them in 1843 to 1846. In 1815, Mr. Charles Baird, an English engineer at St. Petersburgh, applied paddle-wheels with feathering floats to a steamboat which he fitted out to run on the river Neva.

The largest paddle-wheels in use are those of the "Great Eastern" steamship, built 1857. They are 56 feet in diameter, 13 feet deep, and have 30 fixed paddle boards or floats each.

Screw propellers, the present universal means in use for the propulsion of ships, were first conceived and applied by numerous engineers in the early part of this century. The forms of the screw have been the subject of innumerable trials and many patents. The names of Bennet Woodcroft, 1826–1842; the late Sir Francis Pettit Smith, 1836; James Lowe, 1838; G. Rennie, 1839; H. Wimshurst, 1839; R. Griffiths, 1849; H. Hirsch, 1859; and Mrs. Henrietta Vansittart, 1868, are some of the better known names connected with screw propulsion.

The first steamship of war in Her Majesty's Navy driven by the screw propeller was the "Rattler." She was built in America in 1844 and tried in England in 1845. Her screw had only two blades or fans. The screw was cast in gun-metal. Its weight 26 cwt. 2 qrs.; its diameter 10 feet 1 inch; and its pitch 11 feet.

Other means for propelling ships besides paddle-wheels and screws have been brought forward from time to time with more or less success on trial by inventors. Perhaps the more successful of these plans is the system designed by Mr. D. Ruthven about 1860, and tried on board H.M's. iron-built ship "Waterwitch," 162 feet long, 32 feet broad, and 11 feet draught of water; tons 778; horse-power 160, nominal.

Mr. Ruthven's invention is known as 'Ruthven's Hydraulic Propeller." It consists in the application of the turbine wheel driven by powerful steam engines to force water supplied to it through the ship's bottom with great energy, through and out of pipes running along ships' sides about her line of floatation. The water driven out by the turbine impinges with great force against the water outside, and propels the ship either way according to the direction in which the water is forced as controlled by suitable arrangements of water-way valves for the purpose.

Locomotive Engines.

107. WORKING MODEL, on a 1½ inch to 1 foot scale. A FOUR-WHEEL LOCOMOTIVE ENGINE. Built at Alexandria in 1862, for service of Egyptian Railway between Alexandria and Suez, under direction of the late Jeffrey Bey, C.E.

Lent by Mr. Thomas Jeffrey, Manor Farm, Little Ilford, Essex. 1870.

Note.—The model represents an engine of the outside cylinder, "Stephenson" type, on four wheels, and is a tank engine of a peculiar form.

The water tank is hung beneath the boiler, the coal boxes are placed over the fire-box of the boiler.

To the model are attached the necessary accessories of a locomotive engine; lifting screw jack with traverser, screw keys, fire bars, lights, stoking irons, &c., complete.

108. MODEL, in Wood and Brass. Sectional Working Model, of the Cylinder, Piston, Slide-valve, Eccentrics, Link Motion, and other parts of a Locomotive Engine. Constructed under the direction of the late Jeffrey Bey, C.E.

Lent by Mr. Thomas Jeffrey, Manor Farm, Little Ilford, Essex. 1870

Note.—This model also indicates the variable expansion and cut-off of steam in the engine cylinder.

109. WORKING MODEL. T. R. Crampton's EXPRESS LOCOMOTIVE ENGINE. The peculiarities being a very low

centre of gravity and large strong wheels with a minimum of overhanging weight. The whole of the moving machinery is on the outside of the engine. Designed in 1847.

Lent by Mr. Thomas Russell Crampton, Victoria Street, Westminster. 1876.

Note.—The locomotive was designed by Mr. T. R. Crampton for high speed in 1847.

Previous to this engine being designed, no express trains were run on the Continent. For the purpose of running express trains on the railways of France it was selected in 1849 to commence a service between Calais and Paris, since which period to the present time, 1876, the Northern Railway of France express trains have been worked almost exclusively with this system of engine. The model is constructed on a scale of about 1½ inches to 1 foot.

In 1851, at the Great Exhibition, one of these same Crampton express locomotive engines, called the "Liverpool," was exhibited by the London and North-Western Railway Company. It ran on eight wheels, and had cylinders 18 inches diameter, length of stroke 24 inches, and driving wheels 8 feet diameter. The heating surface in the boiler tubes was 2,136 feet, and in the fire-box 154 feet. Weight, in working order, 32 tons. The tender carried coke and water four tons. The evaporation of the boiler at full work equalled 1,140 horse-power; the working steam pressure was 120 lbs. per square inch. All the working parts of the engine were outside of the boiler and at all times in complete view of the driver.

The boiler was of great length and placed on the engine as low as possible. The greatest weights of the locomotive were on the extreme wheels. These arrangements insured increased steadiness of the engine when running.

The locomotive "Liverpool" was built by Messrs. Bury, Curtis, and Kennedy, Liverpool. Modifications of this system for locomotive engines are still in use on the London and North-Western Railway for working quick passenger, mail, and express trains.

The London and North-Western Railway was opened in 1838 as the London, Birmingham, and Liverpool Railway Stephenson was the engineer.

110. LOCOMOTIVE ENGINE. Four Wheel coupled, outside Cylinder Locomotive Engine for 3 feet guage. Weight 3¼ tons in working order.

Lent by Messrs. Black, Hawthorn, and Co., constructors, Gateshead. 1878.

Note.—This locomotive engine is constructed for use on 3 feet guage railways, such as are laid down in dockyards,

arsenals, and for the conveyance of mineral products in mountainous districts. On the level the engine will draw a load of 60 tons. The diameter of the cylinder is five inches, the stroke is 10 inches. A saddle tank for water, holding 50 gallons, rests on top of the boiler, which has a fire-box of copper, and tubes of brass. The working pressure of steam is 135 lbs per square inch. The total heating surface equals nearly 70 square feet. The wheels are 20 inches in diameter, and the wheel-base of the locomotive is 3 feet 1 inch. The engine will travel round curves of 20 feet radius.

111. WORKING MODEL. Scale 1½ inches to 1 foot. Locomotive Engine and Tender. Trevithick's system, six Wheel Outside Cylinder Engine.

Note.—This model of a six wheel locomotive engine, with a four wheel tender, illustrates the system of Trevithick brought out by him some 25 or 30 years ago.

The cylinders, piston, and connecting-rods are placed outside the boiler, but inside the engine frame forward. The slide-valves with the eccentrics to drive them, and the reversing motion on the link system, are placed inside, under the boiler, together with the feed-pumps and all other gear. The engine has central driving wheels not coupled. The tender is complete, carrying fuel and water for the engine, and fitted with breaks, driver's and fireman's tools, implements, and chests. This type of engine is in daily use on the London and North-Western Railway, running fast and express passenger trains.

112. ORIGINAL MODEL of Trevithick's LOCOMOTIVE ENGINE. (Trevithick's Patent, 1802.)

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—Richard Trevithick, C.E., renowned for many remarkable works in engineering, was born in 1771, and died 1833. He invented the high-pressure steam engine in 1796 and patented it. One of these early high-pressure steam engines and boilers of Trevithick, constructed in Cornwall 1811, was exhibited by Mr. Trethuy, of Hayle, at the Royal Agricultural Society's Exhibition at Kilburn, 1879. The working steam pressure in the boiler was 25lbs. per square inch. The engine is remarkable for simplicity and thoughtful detail.

In 1802 Trevithick designed the first locomotive engine which worked with great success. Trevithick's invention may be said to have laid the foundation of all locomotive engines proper, and of the modern portable engine.

113. MODEL. SNOW PLOUGH fitted to LOCOMOTIVE ENGINES. Lent by the London, Brighton, and South Coast Railway Company. 1878.

Note.—The model illustrates a snow plough devised by Mr. W. Stroudley, and used on the locomotive engines of the Highland Railway system in Scotland. The plough differs considerably from those employed on American railways. It completely shelters the fore part of the locomotive, extending in breadth well outside the leading wheels and framing of the engine, and extending in height nearly to the top of the funnel. The model represents a six wheel outside cylinder engine having four wheels coupled, a type of engine in much favour in the present day on British railways.

113*a*. WORKING MODEL of a LOCOMOTIVE ENGINE. Designed by the late Mr. Simon Goodrich, C.E., 1828.

Presented 1874.

Note.—This model was constructed by Mr. Goodrich about 1830, for researches in methods of heating the boiler, and other experiments. The model is incomplete, but is of interest, inasmuch as the driving engines have vertical cylinders fixed on the top of the boiler, whilst the steam ways to the pistons are driven by a three-way valve moved by eccentrics.

114. WORKING MODEL. The Boiler, Engine, and Wheels of a LOCOMOTIVE ENGINE.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—This model was constructed especially to illustrate the reversing apparatus for a locomotive engine. The model is a working model, and the engines attached to the driving wheels will reverse, stop, or start, precisely as in a full-sized locomotive.

115. LINK MOTION; for Reversing the Movement of LOCOMOTIVE and other STEAM ENGINES. Mr. William Howe, Clay Cross, Chesterfield.

Lent 1876.

Note.—This model is in wood, and represents the first design for the link motion by William Howe of the Vulcan Foundry, near Warrington, about 1838. The section of the steam cylinder piston, valve, and foundation frame, were constructed prior to the application of the link motion; and were arranged to illustrate an improved tappet motion. The link was conceived in 1842, and a sketch made of it by William Howe, who applied it eventually to this wooden model. In 1848 the twin-bar link was designed by William Howe and his friend Mr. W. Usher.

116. MODEL, in Wood. Twin-bar LINK, with SLIDING BLOCK; for Driving and Reversing the Slide-Valves of Locomotive and other Engines.

Lent by Mr. William Howe, Clay Cross, Chesterfield. 1876.

117. Two Bearings of Brass fitted with White Metal. For the axles of railway rolling stock.

J. Woods and Co. 1864.

Note.—These bearings have been in use for some years on the Great Western Railway.

118. Reversing Gear, for Steam Engines. Working model. Holt's Patent Steam Engine Reversing Gear.

Lent by Mr. H. P. Holt, 4, Westminster Chambers, S.W. 1879.

Note on Locomotive Engines.

It may be interesting to record here a few facts concerning two of the earliest locomotive engines made in England, which were lent for exhibition in 1876 to the collection of scientific apparatus got together under the direction of the Science and Art Department.

First, "Puffing Billy."—The oldest locomotive in existence, and the first engine which ran with a smooth wheel on a smooth rail. This locomotive was constructed in 1812–13 for Mr. Christopher Blackett, Proprietor of the Wylan Colleries, near Newcastle, under patents granted to Mr. William Hedley. After many trials and alterations "Puffing Billy" commenced regular working in 1813, and ceased his labours only in June 1862. The boiler and engine are mounted on a wood framing. The former has a long return flue, and is egg ended. The working parts of the engine are all carried on the top of the boiler, whilst the steam cylinders are arranged vertically and attached to the boiler's fore end. The steam ports and valves are worked by tappet motion. The driving is effected by intermediate gear wheels put in motion by long connecting rods from the rocking beams of the engine, to cranks on shaft of first wheel. "Puffing Billy" runs on four wheels of equal diameters, 3 feet 3 inches, and has attached a tender on four wheels, constructed with a wooden frame, and carrying a coal-box and water tank. The engine is now in charge of the Commissioners for Patents.

Secondly, "The Rocket."—Constructed in 1829, by Messrs. Stephenson and Co., under direction of George and Robert Stephenson, and celebrated for being one of the competitive locomotive engines in the trials made on the Liverpool and Manchester Railway at Rainhill in October 1829. "The Rocket" competed with two other locomotives, "the Novelty" built by Messrs. Braithwaite and Ericsson and the "Sanspareil" built by Mr. Timothy Hackworth both of which failed on the second day's trials, and gained the prize of 500*l.* then offered to engineers for the best locomotive engine produced. The railway was formally opened for public use in September 1830.

"The Rocket" runs on four wheels. The leading wheels, 4 feet 7½ inches diameter, being the driving wheels. The boiler, constructed on the multi-tubular system, with a fire-box at the back end, is the parent of all the present locomotive engine boilers. The engine cylinders were originally attached to the boiler at its fire-box or back end, in an oblique direction. Their present, nearly horizontal position is an alteration. The slide valves and steam ports are worked by eccentrics and a clutch movement attached to them which is thrown in or out of gear by a foot treadle on drivers foot-plate, effects the reversing of the engine, The framing of "The Rocket" is of iron, and the engine is supported on the wheels by springs. "The Rocket" was sold in 1837, after much hard work on the Liverpool and Manchester Railway, to Mr. Thompson, of Kirkhouse, near Carlisle. It was laid by in 1843–44, at Kirkhouse, and afterwards was put into the care of the Commissioners for Patents.

Multi-tubular boilers appear to have been devised in 1803, by Woolf, whose name is also associated with the system of compound engines. In 1815–29, George Stephenson was experimenting on this type of boiler; and its application to "The Rocket" locomotive was the result.

To George Stephenson, born 1781, died 1848, and Robert Stephenson his son, born 1803, died 1859, must be given the undoubted credit of carrying out to the full the following improvements in locomotive engines:—

1. The adoption and regulation of the steam blast in the chimney of the locomotive for urging the draught of the fire.

2. The fire-box and multi-tubular system for the boiler.

3. The direct action of the engine on the driving wheels, and doing away with the intermediate gearing found in previous engines.

4. The final determination that weight only on a smooth wheel upon a smooth rail would produce any required tractive power in locomotives.

It should be added, that in 1825 George Stephenson launched for service on the Stockton and Darlington Railway one of his earliest locomotive engines, the celebrated No. 1, and subsequently started three others on the same railway. No. 1, worked on the line hauling coal until 1846, when she was laid by. Eventually No. 1 engine was placed on a granite pedestal in front of the Stockton and Darlington Railway Station at Darlington George Stephenson's birthplace, and she stands there as a public memorial to Stephenson. The works at Newcastle founded by the Stephensons for locomotive engine building and engineering have attained to the greatest celebrity for their productions both at home and abroad.

Mention should be also made here of the huge locomotive engines designed about 1847–50 by Brunel for the Great

Western broad gauge system, 1839–1841, capable of maintaining a train speed of 60 miles per hour. One of these engines was exhibited at the Great Exhibition of 1851, the "Lord of the Isles." A full detailed description of it will be found in the Machinery and Railway Section (Class V.) of the Catalogue. These engines still run the express trains between London and Bristol. Brunel also designed the Great Western system of permanent-way, which materially differs from the ordinary system, in that the sleepers run longitudinally as baulks of timber the whole length of the line, and the metals or rails are fastened down upon them. The locomotive engines of the Metropolitan Underground Railway are also worthy of attention and study. They are noteworthy to the student by reason of their great power, and the arrangement provided in them for exhausting, at the will of the driver, the waste steam from the engine into the water-tank carried by it; as well as exhausting it in the ordinary way through the blast pipe in the smoke-box and up the funnel. These engines are known as tank locomotive engines. They have four wheels coupled and a bogie fore-carriage on four wheels. The fuel and water are carried by the engine itself and not by a separate tender. The Underground Railway system was begun in 1860, John Fowler, engineer, as the Metropolitan Underground Railway from Paddington to the City.

Note on Steam Carriages for Roads.

Road steamers or steam carriages of high speed for running on common or ordinary road-ways are of early invention; John Cugnot, a native of Lorraine, being the first constructor in 1763 of this description of steam carriage. From the time of Murdoch at Redruth in 1784 in England, Symington 1794 in Scotland, and Evans 1772 in America, to the present day; many steam carriages have been constructed to run on common roads with more or less success. Griffith 1821, Gurney, Church, Macerone, Anderson, Squire, Hancock 1826, Ogle and Summers 1832, the Earl of Caithness, J. E. McConnell 1859, Charles Randolph, Glasgow, 1871, and others, are known and established names connected with the construction of steam carriages of high speed to run on ordinary road-ways. The invention of Mr. R. W. Thompson of Edinburgh in 1868 of tyres of india-rubber for the wheels of these road steamers greatly confirmed them as a means of locomotion on common roads.

Permanent-way for Railways.

118. ONE Length with Two CHAIRS of the Original CAST-IRON RAIL with Side Cogs. Designed by Blenkinsop in 1811, for the Darlington Railway.

Lent by the Society of Mechanical Engineers. 1876.

Note.—This piece of original rail with its chairs is of cast iron. It is 3 feet 5 inches long, 2 inches wide on the top side, and 5¾ inches in extreme depth, and is made on the "fish belly" plan. In this piece of rail there are seven semi-circular lugs or cogs cast on the outside which is plain or flat, the inside is flanged top and bottom to give a holding for the wooden keys which keep the rail in the chairs. The rail is now the property of the Society of Mechanical Engineers.

After Blenkinsop's invention, came a rail of cast iron devised by Mr. Losh, of Newcastle, 1816. George Stephenson was associated with Losh in the manufacture of this rail, which was a plain rail cast in the fish belly form, but was much heavier than Blenkinsop's rail, and had an over-lap instead of a scarf joint. Cast-iron rails soon gave way to malleable or wrought-iron rails, the use of which was strenuously advocated by Stephenson for all railways, and now nothing else is used, save rails of rolled steel substituted for rolled iron. The present method of holding the rails together and keeping them in one continuous length is called "fishing," or the "fish joint." The rails, which butt end to end throughout, and between the chairs, not at them as in Blenkinsop's rail, are held in their places by a fish, which is a piece of iron or steel made to fit each side of the rail exactly between the top and bottom flanges, and are there held in place by bolts which pass through holes in the fish pieces and the rail, and are held fast by nuts and washers, which are screwed up tight, as occasion requires.

118*a*. RAIL JOINTS. A series of full size illustrations, six in number; Showing specimens of steel RAILS, cast-steel CHAIRS for them, and steel WEDGES for their keys.

Lent by the Acaster Patent Rail Joint Company, Castle Court, Sheffield. 1879.

Note.—The specimens of steel rails, chairs, and wedges illustrate the patent held by the Acaster Rail Joint Company for the employment of a groove cut in the flanges of the rail into which four steel keys are driven to maintain the rails fast in the chairs. The chairs themselves of cast-steel, are also of improved construction and are called elastic.

118*b*. RAILWAY PERMANENT-WAY. Two Models in Brass. Wood's Patent Transverse Wrought-iron SLEEPER

and Patent Clip CHAIR, for iron permanent-way for railways.

Lent by Mr. Charles Wood, Tees Iron Works, Middlesboro'. 1879.

Note.—One of these models represents a sectional view of the rail and its chair, and the other illustrates Mr. Wood's patent transverse wrought-iron sleeper with the detail of his method of holding the rails in position. Messrs. Gilkes, Wilson, and Co., Middlesboro', are the makers of this system of permanent-way.

118*c*. RAILWAY PERMANENT-WAY. Three Models in iron. Livesey's Patent Wrought-iron PERMANENT-WAY; adapted for light railways and for the ordinary narrow and broad guage systems.

Lent by Mr. James Livesey, C.E., 9, Victoria Chambers, Westminster. 1879.

Note.—These three models represent the following features: Mr. Livesey's patent wrought-iron sleepers adapted to light railways; his patent wrought-iron permanent-way used in India and other countries, showing an elastic key-jaw and corrugated wrought-iron key for holding the rails, as well as Mr. Livesey's patent wrought-iron clip for railway metal sleepers. With these models will be found a detailed drawing showing the application of Mr. Livesey's patents in iron railway permanent-way and the method of laying it.

See also page 73.

118*d*. RAILWAY PERMANENT-WAY. The Denham-Olphert Patent Metal SLEEPER for flat-bottomed rails, and a full-size example of their application on the railway systems of East India.

Lent by Messrs. Thompson and Browning, 3, Victoria Street, S.W. 1879.

Note.—These examples of iron permanent-way for railways comprise two models in wood representing full-size the Denham patent sleeper for metre-gauge lines, and the Denham-Olphert patent sleeper for flat-bottomed rails as used in India. There is also a representation of these iron sleepers, with chairs and rails, and showing the stretching-bar connection as actually laid for Indian railways.

119. WASHERS. Grover's Patent Steel Spring HOLDFAST WASHERS. For securing the Nuts of Rail-joints, Fish-bolts, Bolts for Bridge-work, Machinery, Steam Engines, Railway Rolling Stock, and all Bolts subject to vibration or changes of temperature.

Manufactured and lent by W. G. Grover and Co. 9, Victoria Chambers, Victoria Street, S.W.

Lent 1875.

RAILWAY SIGNAL APPARATUS.

119a. FOG SIGNAL.—For Railways.

Lent by Mr. Edward Alfred Cowper, 6, Great George Street, Westminster. 1876.

Note.—This simple little instrument illustrates the application of the science of acoustics to a very useful object, namely, the communication of information from a person on a railway to the driver of a passing train, in a dense fog or on a dark night; it is the only instrument that accomplishes the object, and has been the means of saving many thousands of lives. Invented by the exhibitor in 1841.

The principle consists in producing a very different sound from any that is constantly recurring in a railway train, and a sudden explosion or detonation is found to be the best for the purpose; it is caused by the explosion of a small quantity of gunpowder in a small tin box, by the firing of a match inside which is crushed by the wheel of the passing train.

119b. RAILWAY SIGNAL. Working Model of Radcliffe's Automatic Apparatus for ALARM SIGNALLING in thick weather. On trial on the Great Northern Railway.

Lent by Mr. James Radcliffe, Telegraph Department, Great Northern Railway, Retford. 1879.

Note.—The model represents a distance signal-post and an electric automatic arrangement attached to it, by which, when the signal is set at danger or stop, a lever attached to the locomotive on passing the signal is suddenly depressed, and at once opens the steam whistle of the engine as an alarm to the driver.

Note on Telegraphs.

An electric telegraph was first produced by Watson in 1747, he exhibited the transmission of electricity by an insulated wire in that year. Telegraph arrangements employing electricity were also promulgated by various electricians in 1744, 1787, 1795, 1796. Ampère's (French physicist 1775–1836) arrangement employing the magnetic needle, coil, and galvanic battery was invented 1820. Ronalds also gave an account in 1823 of his electric telegraph.

Wheatstone's telegraph working over four miles of wire was constructed in 1836. Sir William F. Cooke set up an electric telegraph on the Great Western Railway from Paddington to West Drayton 1838–9 and on the Blackwall Railway 1840. In America the first electric telegraph line was set up in 1844 from Washington to Baltimore. In Paris over-house telegraphs were established in 1859. The Atlantic electric cable and telegraph was first promulgated in 1845 by Messrs. W. and J. and J. Brett, and was part laid down in 1857. In August 1858 a telegraph cable was successfully laid across the Atlantic and messages were exchanged between America and Britain.

Telegraphs are virtually of the two following orders or descriptions, visual and aural. Æschylus, B.C. 525–436, the Greek writer, describes communication of intelligence by burning torches as signals, and Polybius, B.C. 122, also describes "Pyrsiæ" or instruments employing fire as a means of communication. In 1663 a telegraph was suggested by the celebrated Marquis of Worcester, and in 1684 by Dr. Hooke. In 1792 M. Chappé invented the first telegraph used by the French; and his telegraph, it appears, was erected at the Admiralty, Whitehall, 1796. The well-remembered semaphore telegraph at the Admiralty was erected 1816. Navy signals were originated by James II., perfected by Admiral Kempenfeldt in 1780, and a dictionary or code-book for them was written by Sir Home Popham. The modern light-flashing and heliograph system of telegraphy by means of artificial lights and mirrors, and flag-signaling for military purposes, are of very recent invention and application. Captain Colomb, R.N., and Captain Frank Bolton are more immediately connected with the development of these systems. The Telephone invented by Professors Bell and Edison, of America, is an illustration of an aural telegraph.

Railway Rolling Stock.

120. WORKING MODEL. Illustrating the System adopted on the Principal Railways of Great Britain for the Service of Her Majesty's Post Office, for the delivery and reception of Mail Bags by mail trains without stopping.

Lent by Her Majesty's Postmaster General. 1876.

Note.—This model represents three of the carriages on the London and North-Western Railway which are used daily for the service of the Post Office. Continuous communication is provided between each carriage, and the model shows the interior arrangements for the reception, delivery, and sorting of letters, while the train is in full journey either by day or night.

Posts are said to have been originated by Cyrus, King of Persia, who erected post-houses and established regular couriers throughout his kingdom about 550 B.C. Augustus, the Roman Emperor, introduced this institution in the Roman Empire, B.C. 31. In France Louis XI. first established post-houses, 1470. They were the earliest post offices in Europe. In England the post office was established in the reign of Edward IV. in 1481, riders on post-horses running stages of 20 miles from each other. Post communication to most of the towns of Great Britain and Ireland existed in 1635.

A penny post was first set up in London and its suburbs by a Mr. Robert Murray, an Upholsterer, 1681. Cross posts

were established by Ralf Allen in 1720. A penny post was established in Dublin 1774.

Mails were first conveyed by horse coaches in England in August 1784, and were first conveyed by railway 1830–1835. In 1837 the late Sir Rowland Hill broached his plan for the present system of penny postage, which was adopted in Parliament 1839.

121. WORKING MODEL, on a scale of $\frac{1}{4}$ inch to 1 foot, of a large sized narrow gauge Railway Cattle Truck.

Lent by Mr. A. H. Bevan, 221, Brompton Road, S.W. 1878.

Note.—This model represents a covered or roofed railway cattle-truck, arranged for carrying water and fodder for live cattle on long journeys. It is the design of the exhibitor, and similar trucks for the transport of live cattle for long distances, carrying fodder and water, are employed on some of the great railway lines of the country.

122. WORKING MODEL, of a Railway Truck, Illustrating W. Stroudley's Improved Buffer and Draw-Bar.

Lent by the London, Brighton, and South Coast Railway Company. 1878.

Note.—This model illustrates Mr. W. Stroudley's plan of arranging the draw-bars of railway trucks in such a manner as that the shocks and strains upon them should be received directly upon the truck framing without jar. The draw-bar head is cushioned with india-rubber butting against the principal beam of the truck frame. The buffers are also improved in their arrangement for resisting shocks on a plan devised by Mr. Stroudley, the Locomotive Superintendent at Brighton, of the London, Brighton, and South Coast Railway. To the rails on which the truck stands are attached models of W. Stroudley's Patent Ramps for remounting, on to the rails or metals, engines, carriages, or trucks, which may have left them.

123. MODEL, in Metal and Wood, of a pair of Railway Carriage Wheels, Mansell's Patent, with W. Stroudley's Standard Axle, 1865.

Lent by the London, Brighton, and South Coast Railway Company. 1878.

124. SECTIONAL MODEL, in Metal and Wood, showing construction of Mansell's Patent Railway Carriage Wheel; with Stroudley's Standard Axle, 1865.

Lent by the London, Brighton, and South Coast Railway Company. 1878.

Note.—The bodies of these wheels are composed of solid oak or hard timber cut into segments and pressed together by hydraulic power to form the complete wheel. The rims

and tyres of the wheels are also put on to them by hydraulic pressure or by the process known as "shrinking on."

125. PHOTOGRAPHS of Locomotives, Rolling Stock, Carriages, Trucks, Steamers, and Works belonging to the London, Brighton, and South Coast Railway Company. 1878.

Lent by the Company. 1878.

126. FULL SIZED working illustration, fitted complete. Electric Communication for use on railway trains between Passengers and Guards. Patented by Stroudley and Busbridge 1875.

Lent by the London, Brighton, and South Coast Railway Company. 1878.

Note.—This illustration represents the invention combined with the communicating apparatus known as the cord system. The passengers communicate to the guard of the train by electric apparatus, and he again to the driver by a cord rove outside the carriages for the entire length of train. The cord is available also for the use of the passengers should the electric apparatus in any way fail.

127. PHOTOGRAPH of Old and New LOCOMOTIVE ENGINES and ROLLING STOCK for Railways; viz.,

No. 1 Engine. Stockton and Darlington Railway. Designed 1825 by George Stephenson.

The Railway Coach "Experiment;" drawn by horses for passenger traffic, on Stockton and Darlington Railway; 10th October 1825.

Portraits of Railway Pioneers. George Stephenson, Edward Pease, and Francis Newburn.

Photographs of Modern Locomotive Engines and Railway Carriages.

Two hand-bills or time-tables announcing for public use the departures and arrivals of the railway coach "Experiment" and the opening of the Stockton and Darlington Railway for general use in September 1825.

Presented by Mr. A. Marshall, Perseverance Iron Works, Heneage Street, Whitechapel. 1878.

128. OLD RAILWAY HAND-BILL, dated 1st June 1804. Announcing the completion of the first section of the Surrey Iron Railway.

Lent by Mr. Trovey Blackmore, 2, Ashley Road, Wandsworth. 1876,

Note. This railway, which is believed to have been the first railway established in England for public traffic, was made pursuant of an Act of Parliament passed in the year

1801, by which the company was empowered to raise a capital of 30,000*l.* in shares of 100*l.* The railway was first opened from Wandsworth to Croydon, and was subsequently extended to Merstham. It passed through the valley of the Wandle, a district abounding in mills of various kinds, and conveyed the manufactures and produce of the district to the Thames at Wandsworth, where a terminus was built with large store-houses and a wet dock for the convenience of lading and unlading goods carried by water. This terminus is still in existence, though now appropriated to other uses. Large quantities of coals were conveyed inland by this railway. The rails were laid upon stone blocks or sleepers, and the cars were drawn by horses and mules. The railway was in operation till about the year 1851, soon after which time the company was wound up and the plant and property sold.

Caloric or Hot-Air Engines.

Note.—The Rev. Robert Stirling of Galston, N.B., originally took out a patent in 1816 for a hot-air or caloric engine. This design came to nothing. In 1827 Rev. R. Stirling took out another patent for a caloric engine which worked successfully. Glazebrook 1797, Medhurst 1799, Bompas 1828, Ericsson 1851–60, Napier and Rankine 1853, Siemens 1855, and Schwarz 1864 constructed caloric engines.

129. MODEL, in WOOD, of a CALORIC or HOT-AIR ENGINE. Unfinished.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—The model represents a hot-air engine of American design. The engine consists of two cylinders, the larger of which may be called the compressed or cool air cylinder, and the other, the driving or hot-air cylinder. The combination of a hot and cold air cylinder is common to all caloric engines, prime movers driven by heated air.

130. CALORIC OR HOT-AIR ENGINE. Half Horse-power, Rider's Patent; Walden, New York.

Lent by the makers, Hayward Tyler, and Co., 84, Whitecross Street, E.C. 1877.

Note.—The motion of this engine is derived solely from the use of air. The engine consists of two upright cylinders, one called the "compression" cylinder, and the other the "power" cylinder. Plungers work in the cylinders and are connected by means of connecting-rods to a crank-shaft carrying a fly-wheel. One of the cylinders (the power cylinder) passes down into a heating stove lined with fire brick, the other cylinder (the compression cylinder) is surrounded by an annular space or casing through which cold

water is constantly circulated. In the compression cylinder the air is cooled and compressed by the descending plunger. The air then passes over into the power cylinder, and coming into contact with its heated parts, rapidly expands and drives up the plunger, thus giving motion to the crank-shaft. Immediately after this operation the heated air passes back again to the compression cylinder (to be again cooled and compressed) through a box containing a number of thin iron plates which, while affording a free passage to the air, subdivides it into thin sheets. This box is called the regenerator, and is so placed between the cylinders as to be traversed by the air in its passage each way between the hot and cold cylinders. By means of this regenerator the heat is alternately abstracted from and returned to the air in its passage backwards and forwards through the plates. The same air is thus continually used to drive the engine, which has no internal working parts except the two plungers and connecting rods, and no exhaust. The engine exhibited is of half a horse-power, nominal, and consumes 2½ to 3 lbs. of coke per hour.

Gas Engines.

NOTE.—Prime movers, driven by a proportionate admixture of coal gas and air, which being suddenly ignited by artificial means at each side of the piston in the cylinder drives it backwards and forwards, as the steam in an ordinary steam engine, have been used for some years past.

The earliest motor of the kind was the Lenoir engine, a French invention and arrangement, which was introduced in 1860. This was followed in 1869 by the Hugon engine, which was a considerable modification and improvement of the Lenoir engine, and did away with much of the complicated arrangement in it.

The Hugon has been again succeeded by the gas engine of Messrs. Otto and Langen, brought out about 1873, and known as the jumper, from the peculiar jumping action of the driving piston caused by the explosion under it of mixed gas and air. The piston is driven upward by the exploded gas and air in a vertical cylinder, and driven downward by atmospheric pressure, the cylinder being open at the top. The Otto and Langen engine made by Messrs. Crossley Brothers, Manchester, is now considerably modified in its detail, and approaches the simplicity of, and has many of the features of an ordinary horizontal steam engine.

An engine of 3½ nominal horse-power of this latest form of horizontal gas engine constructed by Messrs. Crossley Brothers under Otto and Crossley's Patents,

1876–7, was exhibited at work and driving printing machinery at the Caxton Celebration Exhibition of 1877. The engine will give a maximum break power of about four horses, and the cost of the gas consumed is about one penny per hour per "indicated" horse-power. The price of the gas being 4*s.* per 1,000 feet. The piston of this gas engine is driven on one side only by the ignition and explosion of mixed gas and air while the return stroke is made by the momentum of the fly-wheel, the cylinder being open at one end. There is an annular space or jacket round the cylinder in which a cold water supply must be circulated to keep the cylinder cool. To start the engine, turn on the gas supply, light the gas jet at the back end of the cylinder, and help the fly-wheel in the ordinary manner. These engines are fitted with sensitive governor and throttle or controlling valve, which appear to govern the engine in working with great nicety.

Another form of gas engine was brought out in 1877, by Messrs. Louis Simon and Son, Nottingham, under Messrs. Gilles and Humboldt's Patents. An upright cylinder open at both ends has within it two pistons. One of the pistons is loose on the piston rod, the other is connected in the usual method to the crank-shaft and fly-wheel. The loose piston being driven upward in the cylinder by the ignition and explosion under it of mixed gas and air, is held by a catch at the top of the cylinder. This action produces a vacuum in the cylinder, and consequently allows the second or driving piston to be forced inwards by atmospheric pressure. The loose piston is now released from the catch, and both fall downwards. These operations are repeated, and hence an up and down stroke of the pistons in the cylinder is maintained. A small gas jet ignites the mixed gas and air. The cylinder being open at both ends, a water jacket to keep it cool is not required This engine has been entirely altered and greatly improved, 1879.

A compact and ingenious engine on the rotary principle, to be driven by gas and air, the invention of Mr. J. Ford, Engineer of the Patent Office Museum, was brought out by him in 1876, and is now manufactured by Messrs. Young and Co., of Pimlico. Several new forms of gas engines are now extant. Amongst them Bisschop's well-known engine, made by the Sun Lighting Co., Southwark Street, and others; Clayton's gas engine, made by Thwaites and Carbutt, Bradford; Turner's engine, S. Alban's; and Clerk's, Messrs. Thomson, Sterne, & Co., Glasgow.

130*a*. 3½ Horse Power Horizontal GAS ENGINE, with two fly-wheels, Otto and Crossley's patent, 1876.

Lent by Messrs. Crossley Brothers, Great Marlborough Street, Manchester, and 116, Queen Victoria Street, E.C. 1879

Note.—This gas engine, as now constructed by Messrs. Crossley Brothers, resembles closely an ordinary horizontal steam engine. It works smoothly and silently. Diameter of cylinder 8 inches; length of stroke 15 inches; diameter of fly-wheels 5 feet. The engine runs at about 160 revolutions per minute.

Engine and Boiler Accessories, and Fittings.

BOILER FEED PUMPS.

131. STEAM DONKEY ENGINE and PUMP. Single-acting, for feeding Steam Boilers with water.

Lent by Makers, Messrs. Alexander Wilson and Co., Engineers, Vauxhall Works, Wandsworth Road, S.W. 1871.

Note.—Diameter of steam cylinder, $3\frac{1}{8}$ inches; stroke, 4 inches. Diameter of pump, $1\frac{7}{8}$ inches. Will pump 460 gallons per hour, and feed a 30 horse-power steam boiler.

132. Three MODELS, in Brass; showing in section the arrangement of GIFFARD'S PATENT INJECTOR for feeding Steam Boilers with water.

Lent by Messrs. Sharp, Stewart, and Co., Engineers, Manchester, and Victoria Street, S.W. 1870.

1. Giffard's own Patent Injector in section.
2. Giffard's Injector in section; with the Patent Adjustment of Messrs. Robinson and Gresham.
3. Giffard's Injector in section; with Seller's Patent Adjustment.

133. DRAWING, on a Scale of 6 inches to 1 foot. An Improved Donkey STEAM ENGINE AND PUMP for feeding Steam Boilers with water.

Presented by Messrs. Alexander Chaplin and Co., Engineers, Glasgow. 1874.

134. PHOTOGRAPH of a Double-action STEAM PUMP AND DONKEY ENGINE for feeding Steam Boilers with water.

Presented by Messrs. Brotherhood and Hardingham, Engineers, London, E.C. 1874.

135. PHOTOGRAPH of a Single-action STEAM PUMP AND DONKEY ENGINE for feeding Steam Boilers with water.

Presented by Messrs. Brotherhood and Hardingham, Engineers, London, E.C. 1874.

SAFETY AND OTHER VALVES.

136. DRAWINGS of SAFETY VALVES of Marine Steam Boilers: for lecture purposes.

Lent by J. F. Flannery, 9, Fenchurch Street, E.C. 1877.

Note.—The drawings relate exclusively to spring safety valves for marine boilers, and show in section the following different varieties:—

Diagram 1. Theoretical principles, Normal pressure 60 lbs. per square inch.

Diagram 2. Adams' patent safety valve. Spring loaded valve. Arranged to blow off at 70 lbs. per square inch.

Diagram 4. Safety valves on the boilers of Chinese gun boats "Foo So," and others.

Diagram 5. Safety valves on the boilers of the Chinese steamships "Kong-gi" and "Hi-yei."

Diagram. Turton's patent compensated spring loaded safety valve. This valve is held in place by upright bars of various metals which "compensate" or equalize the pressure they maintain on the valve under the varying conditions of heat and cold to which they are liable in working.

Diagram. An ordinary spring safety valve in section.

See also page 30.

136a. STEAM QUIETING CHAMBER. P. S. Justice, Patentee.

Lent by Mr. G. Beck, 37, Devonshire Street, Queen Square, W.C. 1879.

Note.—The object aimed at by Mr. Justice in his invention of the steam quieting chamber is to overcome the roaring noise of the steam "blowing off" or escaping from the boilers of steamships, locomotive engines, and steam boilers in general.

ENGINE GOVERNORS.

137. WORKING MODEL. Showing the Relative Effect of Hanging the Arms for the Balls of a Steam Engine Governor from different points with respect to the axis of rotation.

Presented by Mr. Jeremiah Head, M. Inst. C.E., Middlesborough. 1876.

Note.—By turning the horizontal sheave upon the model with gradually increasing velocity, it will be seen that the cross-armed, or approximately parabolic governor, goes through its range with the least variation of speed. Next in efficiency is that wherein the arms are hung from the central axis; whilst the very common form wherein the arms

are hung externally, is the least efficient. In other words, this last form permits the greatest variation in speed between fully opening and fully closing the throttle-valve.

138. PATENT STEAM ENGINE GOVERNOR. Gyrometric. Adapted for a 4-inch Steam Pipe.

Lent by Mr. Scott Moncrieff, Glasgow. 1876.

Note.—This is an apparatus in which the centrifugal force of a fluid is so applied as to regulate the aperture of a throttle-valve through the movements of a loaded piston. It consists of two chambers containing fluid, and communicating with each other through a turbine wheel with four or more straight radial arms. The speed of this wheel depends upon that of the prime mover by which it is driven, and the pressure in the front chamber is dependent upon its velocity, and its variations open and shut the throttle-valve.

In the pendulum governor the centrifugal force and the speed necessary to maintain it vary with the different planes of rotation due to different positions of the throttle-valve. Such an apparatus can only be correct for one position, and errors of speed must occur for every change in the power of the prime mover or the work it is performing, unless these vary simultaneously and equally. In this governor the centrifugal force of the fluid remains in a fixed ratio to the speed of the engine, and the length of the connexion to the throttle-valve varies with the altered length of the fluid column supporting the piston. By adjusting the load upon the piston any speed which the engine is capable of maintaining can be given, and will remain constant for all variations of power and work. An index of the speed may be obtained by attaching a glass or Bourdon gauge to show the varying pressures.

138*a*. GOVERNOR. Marine Engine GOVERNOR; for controlling Marine Engines. Dunlop's Patent Pneumatic Governor.

Lent by Messrs. Cunliffe and Dunlop, Port-Glasgow. 1879.

Note.—The action of this governor is as follows: An air chamber, usually placed at the stern end of the ship, is connected by a sea-cock with the sea, which entering compresses the air in the chamber to a pressure due to the height of the water outside. By means of an air pipe leading to the engine room, this compressed air is conveyed to the second part of the apparatus. This comprises an air vessel having its lower part closed air-tight by an india-rubber diaphragm, held down by a spring adjustable by a screw and nut according to the draught of the ship. The rising and falling action of the ship controls the rise or fall of the diaphragm of india-rubber, which diaphragm again controls, by suitable

arrangements, the cut-off or admission of steam to the engines through the throttle valve or equilibrium valve, and so regulates their speed. This governor has been in use over seven years, both in H.M.'s ships of war and on board some of the largest commercial steamships.

Note on Steam Engine Governors.

There was exhibited at the Scientific Apparatus Exhibition, South Kensington, 1876, an improved form of steam engine governor by Dr. C. W. Siemens; namely, a gyrometric governor, the principle of which consisted of an open cup of parabolic shape, fixed upon a vertical spindle, and caused to revolve within a closed chamber containing a liquid, the bottom of the cup being open and always immersed below the surface of the liquid. When the cup is made to revolve rapidly, the liquid contained in it rises round the sides of the cup and sinks in the centre, the surface of the liquid assuming the inverted parabolic form; and on reaching the edge of the cup it overflows into the surrounding chamber, while at the same time a fresh supply of liquid is drawn into the cup through the opening in the bottom; and the power absorbed in putting the overflowing liquid into motion offers a continuous resistance to the rotation of the cup. On a level with the edge of the cup, a series of fixed vanes are placed round the circumference of the external chamber, and a corresponding set of blades are also fixed round the outside of the cup just below the rim, so that the sheet of liquid overflowing from the edge of the revolving cup is thrown against the vanes, and by these is thrown back against the blades on the cup, whereby the overflowing liquid is made to offer an additional resistance to the rotation of the cup.

The internal radial arms uniting the shell of the cup to the centre boss serve to communicate the rotary motion to the liquid inside the cup, while the bottom of the external chamber is provided with a number of radial ribs, for the purpose of checking rotary motion in the liquid outside the cup.

So long as the cup is driven at a constant speed, the overflow is constant, and produces an absolutely constant resistance; and hence, if the cup be driven by a constant driving power, independent of the engine, its speed is as uniform as that of a chronometer, within a very small margin of variation, which is definitely fixed; and it continues revolving at an unchanging speed, totally independent of the engine, and consequently affords the means of forming a governor for controlling the speed of the engine to a constantly uniform rate.

Dr. C. W. Siemens is also the inventor of a chronometric governor for controlling prime movers, patents for which

principle were granted to Joseph Wood in 1844, and Charles William Siemens in 1845.

CONDENSERS.

139. McCARTER'S PATENT CONDENSER. Model.—Applicable to Steam Engines, and other purposes where a vacuum is required, effected by the Condensation of Steam, without the use of an Air-pump, and capable also of drawing its own injection water.

Lent by Mr. James Wood, Burnley. 1876.

Note.—The condenser consists of two chambers, one above the other. The upper chamber (H) is for condensing the steam, the lower one (G), with the two tappet valves (C and D) opening into it, removes the condensed water from the upper chamber into the hot water cistern, whence it flows away.

The exhaust steam from engine enters at A, meets the injection water entering at B, and is condensed, thus forming a vacuum, the water falling to the bottom of chamber (H). To remove this water, a vacuum is alternately created and destroyed, six times per minute only, in the lower chamber (G), by alternately raising the steam or water tappet valve (the steam supplying the tappet valve being reduced by reducing valve to 2¼ lbs. pressure). On a vacuum being created in lower chamber, the water collected in upper chamber is drawn down through india-rubber foot valve (E); and on vacuum being destroyed in lower chamber, the water falls out through the delivering valve (F) into waste water cistern.

There will be found in the Museum exhibited in the collection of machinery models, a series of five lithographs of McCarter's Patent Condensers properly lettered and numbered. The references in this note refer to these lithographs.

Pressure and other Gauges, Lubricators, &c.

GAUGES AND OTHER OBJECTS.

140. *a.* A 5-Inch PEARSON'S PATENT LUBRICATOR for Steam Cylinders, and other working parts of machinery.

b. Mercury VACUUM GAUGE, for Condensing Steam Engines.

c. THERMOMETER for measuring High Temperatures.

d. Bourdon's Patent STEAM-PRESSURE GAUGES, for high and low pressure boilers.

e. Bourdon's Patent VACUUM GAUGES.
f. Schäffer's Patent STEAM-PRESSURE GAUGES, for high and low pressure Boilers. Two of these gauges are in section showing interior arrangement.
g. Schäffer's Patent VACUUM GAUGES, for condensing Steam Engines, &c.
h. Schäffer's Patent HYDRAULIC-PRESSURE GAUGES, with maximum indicators.
i. BLAST FURNACE GAUGE, Mercury; indicating 6 lbs. pressure.
k. 7 FIGURE, COUNTER; in Section, for counting Steam Engine revolutions, and speeds of Machinery.

Lent by Messrs. Schäffer and Budenberg, Southgate Street, St. Mary Street, Manchester. 1874.

141. SALINOMETER; How's Patent. For measuring the quantity of Sea Salt in Marine Steam Boilers.

Lent and made by Mr. T. O. Buss, Hatton Garden. 1874.

Note.—In using the Salinometer, the water drawn from the Boiler should be at 200° Fahrenheit. The instrument is adjusted for this temperature. It is graduated from 0· to 4·32.

0· Fresh water. 1·32 Sea water, which contains 1 lb. of salt to 32 lb. of water. 2·32 indicates 2 lb. of salt to 32 lb. of water; and so on.

To keep a Marine Boiler clean, the water should not contain more than 2 lb. of salt to 32 lb. of water.

142. REVOLUTION INDICATOR; for indicating constantly the number of Revolutions per minute made by Steam Engines and Machinery.

Designed by Mr. James Wimshurst.
Lent 1876.

Note.—This constant speed indicator is of early date. There are now many machines of this kind used for indicating the speed of machinery. Amongst them may be mentioned Weir's Patent, 33, Abchurch Lane, E.C. The Strophometer made by Elliot Brothers, Strand; Butler's Patent, J. and J. Butler, Belfast, and others.

142*a*. SPEED COUNTER. A Pocket SPEED COUNTER for counting the velocity of moving machinery. A. Sainte's Patent.

Lent by Mr. R. Applegarth, Agent, 25, Abchurch Lane, Lombard Street, E.C. 1879.

Note.—Handy speed counters are indispensable to engineers.

The instrument can be instantly set to zero, and having a separate set of figures for forward and backward motions, the number of revolutions can be read off without making a subtraction sum. In addition to the steel bit usually employed to communicate the motion of an axle to the counter a little boxwood wheel and a steel punch with a silk thread are provided. The wheel is the tenth of a yard in circumference, and measures the forward motion of a pulley band. The punch may be required to make a small hole in an axle to receive the steel bit; the silk thread measures exactly the length of the pendulum; the oscillation of the punch attached to it beats a second and marks a minute accurately.

143. Specimens, full size. Steam Cocks; Steam Boiler Water Gauges, Water Cocks, and others; with Packings of Asbestos; the use of which substance for these purposes is patented by the exhibitors.

J. Dewrance and Company, 176, Great Dover Street, S. Lent 1876.

Note.—This entirely new principle of making cocks and valves with a bearing of asbestos, which is indestructible by heat and most of the acids, instead of the usual metal surfaces which have to be ground together to make them tight, has stood the test use.

Model of 1½ in. cast-iron cock all nickel plated.
Drawing, framed, of 3-in. cock.
Model of 3-in. cock, cast-iron, flanged.
Do. 2-in. do. do.
Do. 1¼-in. do. do.
Do. gun-metal shell and two cups.
Do. gun-metal 1-in. cock.
Do. ¾-in. water gauge.
Do. ¾-in. do. three-way.
Do. nickel plated cast-iron plug.

With these steam-cocks and other fittings illustrating the application of asbestos for packings will be found a detailed working drawing of one of the steam cocks or valves, showing packing.

144. Steam Valves. Holt's Patent. Two Gun-metal Steam Stop Valves.

Lent by Mr. H. P. Holt, 4, Westminster Chambers, S.W. 1879.

145. Steam Cylinder, Drain, and Escape Valve. Dawe's Patent.

Lent by Mr. H. P. Holt, 4, Westminster Chambers, S.W. 1879.

See also page 47.

146. SLIDE VALVE MOTION. Working Model of Halpin's Slide Valve Motion; for rapid cut-off and increased steam expansion.

Lent by Mr. D. Halpin, 7, Victoria Road, Charlton, S.E. 1879.

See also Appendix, p. 192.

148. WATER GAUGE GLASSES, for steam and other boilers. John Moncrieff, North British Glass Works, Perth.

Lent 1879

Note.—These gauge glasses are specially manufactured for boiler purposes. In the show case are 17 glasses of various sizes and lengths, and one glass of the average size in use is fitted up in the usual manner of application.

149. MODEL, in Brass. Faull's Patent Metallic PACKING, for Piston rods, Pump rods, and all packing purposes.

R. Faull, Engineer, 4, Ruperra Street, Newport, Monmouth.

Agent, R. Alexander, 26, Cawdor Street, St. Leonard's Road, Bromley, E. 1879.

Note.—The metallic packing is made from D. P. Matthew's bronze, it has been applied to land and marine engines since 1878.

150. Ten samples of PATENT PACKING; for steam and other joints. 1879.

Lent by Messrs. Davis and Henwood, 28, Budge Row, E.C. 1879.

Note.—It is stated that in the manufacture of this packing no corrosive ingredients or acids and deleterious chemicals are used. It has been tested to 800 lbs. per square inch under hydraulic pressure, and 250 lbs. per square inch under steam pressure.

151. ASBESTOS. Samples of ASBESTOS, raw and manufactured, now largely used for packing the moving parts of steam engines and other machinery.

Lent by the Italo-English Pure Asbestos Company, 11, Queen Victoria Street, E.C., A. Allport, Secretary. 1879.

Driving Gear, Shafting, Millwork.

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160. MODEL of the SHAFTING for Driving Machinery; Erected by the French Imperial Commission in 1855 for

driving machinery in motion at the Paris Universal Exhibition of that year.

Made by Messrs. Nepveu and Co., Engineers and Contractors. Paris, 1855.

Presented by the late Captain Francis Fowke, R.E.
1869.

161. Model, in Wood. Clutch for coupling Driving Shafts for Machinery.

Mr. Jeremiah Head, M.I.C.E., Middlesborough.
Presented. 1876.

Note.—This clutch is capable of adjustment, and shows the method adopted for driving shafting at a slight angle, as well as in a direct line.

Note on Millwork; Shafting, &c.

It may be well to place on record a few facts connected with the science of mill-work, for the information of the student of applied mechanics.

The modern system for mill-work, which includes the transmission of power from the prime mover to all the several moving parts of mill machinery, owes its present successful application and execution to the late Sir William Fairbairn, Bart., F.R.S., of Manchester. He was born at Kelso in 1789; was created a baronet in 1869 for his eminent services rendered to the theory and practice of mechanics and engineering science. He died in 1874.

Sir William Fairbairn's published treatises and papers on all kinds of mechanical and scientific research are text books of the day, and are valuable as standards of facts.

Sir William Fairbairn started a business in Manchester for himself as a mill-wright in 1817. He at this time devoted himself to the repair and construction of water mills and windmills, the gearing and driving powers of which were then constructed of wood, and moved with very slow speed.

Sir William Fairbairn soon turned his attention to the application of iron for his mill-work, in lieu of wood. He speedily brought out the present system of driving-shafts of wrought-iron running at high speed, for mills; and invented the circular half-lap coupling for connecting the several lengths of the shafts together. He also constructed water-wheels entirely of iron in lieu of wood, about this time; and to his skill and ingenuity is due the existence of some of the largest iron water-wheels in Britain and the Continent.

In connexion with this subject of mill-work, Sir William Fairbairn advocated the use of tooth-wheel gearing in lieu of driving bands or straps, for the first motions from the

prime mover to the shafting. In 1855, at the Paris Exhibition of that year, he exhibited at work a vertical high-pressure steam engine of 12 nominal horse-power, and a range of high-speed wrought-iron light overhead shafting which was driven by toothed gear on the engine fly-wheel in direct contact with a toothed wheel or spur wheel on the shafting. This arrangement afforded at that time a great interest to mill engineers. It drove the British spinning and weaving machinery, exhibited in motion at the Exhibition. The plan is still adopted for first motions in mills, but usually for underground shafting only.

In lieu of the leather driving bands or straps used in transmitting power over a mill, it has been lately found advantageous to substitute for the leather, driving bands of rope made specially for this purpose. These rope driving bands have been successfully applied to spinning mills in Dundee by Messrs. Pearce Brothers, of the Lillybank Foundry, Dundee. Rope driving-bands for first motions, as well as for transmission, have been adopted by Messrs. A. and J. Nicoll in their jute spinning and weaving mills, at Dundee, 1877.

The rope driving-bands must run in grooves formed on the face of the rims of engine fly-wheels and first motion drums or pulleys on shafting. With this arrangement the power can be taken off from the fly-wheel of the engine in either direction simultaneously, that is, with a right and left-hand lead. It is said that as many as 16 ropes have been carried over the same fly-wheel to transmit power, seven ropes running one way and nine in the opposite direction.

No. 188.—Collection of the Original Models of Steam Engines and other Machines of James Watt, 1736–1819.

PRESENTED TO THE SOUTH KENSINGTON MUSEUM BY MESSRS. JAMES WATT AND CO. OF BIRMINGHAM; PER MR. G. HAMILTON. 1876.

188. 1. IMPERFECT MODEL. Method of converting Reciprocating into Rotative motion by means of teeth or pins fixed to the connecting rod, which take hold of teeth in a wheel, and cause it to revolve. Some point of the connecting rod being guided by a pin, moving in a groove, so as to keep the teeth or pins always engaged in the teeth of the wheel. *James Watt.*

Note.—This method of converting reciprocating into rotative motion is included in Specification of Patent granted to James Watt, dated October 25th, 1781.

188. 2. Two Fragments of a Model. Consisting of wood rods with oval holes geared internally, and apparently belonging to one of the models selected from the Soho Works by the late Sir Francis Pettit Smith, as an illustration of one of the methods of converting reciprocating into circular motion. *James Watt.*

188. 3. Model of Grinding Mill. Six pairs of stones in two sets of three pairs each, each set driven by a spur wheel with bevil gearing. The two fly wheels are connected and driven by pin and connecting rod. *James Watt.*

188. 4. Model of Grinding Mill. Six pairs of stones, in two sets of three pairs each. Each set driven from one spur wheel by bevelled gearing. *James Watt.*

Note.—The two fly wheels are connected, and driven by one connecting rod, fitted with two sets of stepped sun and planet wheels.

188. 5. Model of Rolling and Slitting Mill. Driven by two connecting rods, on one beam, and fitted with sun and planet stepped gearing. *James Watt.*

Note.—This improvement, consisting of new methods of applying the power of steam engines to move mills for rolling and slitting iron and other metals, is included in Specification of Patent, granted to James Watt of Birmingham, and dated April 28th, 1784.

188. 6. Model of Rolling Mill. Driven by a connecting rod, fitted with stepped sun and planet motion, and with two fly wheels. *James Watt.*

188. 7. Model of two Tilt Hammers. At right angles to each other, one hammer actuated at the tail by cams, the other by lifting cams, driven by one connecting rod fitted with stepped sun and planet motion. *James Watt.*

Note.—Part of the above model is missing, and the helve of one tilt hammer is broken.

188. 8. Model of Wheel. (Probably for grinding.) With sliding axle. To be driven by horse-power. *James Watt.*

188. 9. Fragment of Model. (Probably a Pump Bucket.) *James Watt.*

Models on a Stand. Four trussed beams. Probably used experimentally for testing the strength of different

methods of trussing the beams of pumping engines, and for other purposes. *James Watt.*

188. 10. FRAGMENT of a Model. Frame for a Marine Steam Engine. *James Watt.*

188. 11. MODEL. FRAGMENT of a Frame for a Machine. *James Watt.*

188. 12. MODEL of a Horse Mill. With roller and trough, apparently designed for crushing material. *James Watt.*

188. 13. MODEL of a Train of Wheels. *James Watt.*

188. 14. MODEL of Engine Beam and two Connecting Rods. With universal motion at their upper ends, and connected to transverse hinged links at their lower ends. *James Watt.*

188. 15. MODEL of Beam Pumping Engine. Single acting and condensing engine, worked by tappet valve motion. *James Watt.*

188. 16. MODEL of inverted Cylinder. Steam engine cylinder for a direct-acting pumping engine with tappet valve motion. *James Watt.*

188. 17. MODEL of double acting Beam Condensing Engine. Conical valves worked by eccentric. *James Watt.*

188. 18. Sectional MODEL of Beam Engine. Worked by eccentric and hollow valve. *James Watt.*

188. 19. Sectional MODEL of a Steam Engine. With shifting eccentric for altering the throw of, or reversing the slide valve. *James Watt.*

188. 20. MODEL of a Pair of Tilt Hammers. Arranged alongside each other. Meaning Two Beams and Connecting Rods, with cranked pins at an angle to each other; one of the wheels provided with a balance weight. *James Watt.*

Note.—Part of the above model missing.

188. 21. Fragment of a MODEL, with part of Sun and Planet motion. *James Watt.*

188. 22. Fragment of a MODEL, with sun and planet motion and weighted disc. *James Watt.*

188. 23. FRAGMENT of a MODEL. An Arch Head. *James Watt.*

188. 24. MODEL of a Water Wheel. *James Watt.*

188. 25. A MEASURING APPARATUS, with Micrometer Screw. For taking end measures. *James Watt.*

188. 26. MODEL of Garnet's Patent Friction Rollers. *James Watt.*

188. 27. MODEL used for Testing Pressure due to a Vacuum. *James Watt.*

188. 28. MODEL of a Valve with Universal Joint. *James Watt.*

188. 29. Brass MODEL in Two PIECES. *James Watt.*

188. 30. MODEL, in Wood, used for Experiments on the Governor for Steam Engines. *James Watt.*

188. 31. Experimental MODEL. *James Watt.*

188. 32. Experimental MODEL. *James Watt.*

188. 33. Experimental MODEL. *James Watt.*

188. 34. Original MODEL of a Cylinder for a Steam Engine; with Separate Condenser. *James Watt.*

188. 35. MODEL of Surface Condenser. For condensing steam with greater rapidity than in the old form of condenser. *James Watt.*

Note.—Surface condensers, for marine steam engines especially, are now of universal adoption.

189. BAR LATHE. Full Size. Used by James Watt and constructed by himself.

Lent by Bennet Woodcroft, Esq., F.R.S. 1876.

NOTE ON THE INVENTIONS OF JAMES WATT. 1736–1819.

James Watt, the celebrated mechanician and engineer, was born in Scotland on 19 January 1736 and died 25 August 1819 in England.

In 1758 Watt began his researches for the use of steam as a motive power.

His first invention was a high-pressure steam engine, which he constructed in 1761.

The steam engine known as Watt's Condensing Engine was first devised in 1763 to 1765. A larger engine on the con-

densing principle was constructed by Watt in January 1769, and was patented by him in that year.

In 1774 James Watt joined Matthew Boulton, of the Soho Works, Birmingham, as his partner; and at these works the construction of steam engines made rapid progress, and ultimately established the fame of the "Boulton and Watt steam engines."

Watt devised and originated the following improvements in the steam engine:—

a. The uniformly steam-warmed cylinder, by means of a steam jacket outside it.

b. The steam-driven piston, on the double action principle, which included the invention of the D slide valve to the cylinder moved by a wheel on the engine shaft called the "eccentric," through a long rod attached to the wheel by suitable means and called the eccentric rod.

c. The D valve which admits the steam at the upper and under side of the piston alternately, and affords means for its immediate escape when it has accomplished its work in driving the piston upwards or downwards in the cylinder.

d. The condensation of the steam used in the cylinder in a separate vessel called the "condenser;" from which the air and water is exhausted by each stroke of an air pump worked by a rod from the beam of the engine. The previous method for condensing the steam was to let cold water into the steam cylinder itself.

e. The connection of the piston rod with one end of the beam by the arrangement of jointed rods known as the "parallel motion."

f. The regulation of the supply of steam to the engine by means of the "governor;" which receives motion from the main shaft, and acts upon a valve called the throttle-valve, which valve is opened or shut regularly by the governor according as the engine varies in its speed in working, and in driving the machinery in connection with it.

g. The "sun and planet:" motion for driving the fly wheel and shaft of the engine.

The invention of the crank to drive the fly-wheel and engine shaft and obtain a rotary motion was disputed against Watt for many years by Pickard (1780) who obtained a patent for the crank, although Watt seems to have applied it for driving the engine shaft and fly-wheel contemporaneously.

James Watt invented the copying press, also a system for warming dwelling-houses by steam, and the process of bleaching fabrics by chlorine. He also attained most nearly to the discovery of the composition of water, which was the triumph about 1784 of the celebrated Henry Cavendish, Physicist, born 1731, died 1810.

In 1755 James Watt came to London. He there lived for one year, and pursued the trade of a mathematical instru-

ment maker. Afterwards he retired to Glasgow, where, being unable to establish a shop, not being a freeman of the borough, he retired for study to the university. James Watt also during some part of his career, and before he joined Matthew Boulton at the Soho works as partner, practised as a civil engineer, and carried out various engineering works, canals, bridges, harbours, &c.

The great genius of Watt in the knowledge and conception of mechanical science is amply indicated by the very valuable collection of models made by himself illustrating his various trials and experiments for numerous purposes, which are contained in the foregoing group from Pages 68–71. These models constitute an exceedingly interesting and valuable gift to the Museum, on the part of Messrs. James Watt and Co., of Birmingham, the present firm of engineers.

Tramways.

PERMANENT-WAY FOR TRAMWAYS.

200. TRAMWAY RAILS. Sectional models in wood and iron, full size. Patent TRAMWAY RAILS and SLEEPERS.

Lent by Mr. James Livesey, C.E., 9, Victoria Chambers, Westminster. 1879.

Note.—The sectional model in wood represents Messrs. Livesey and Cameron's patent system of tramway rail and sleeper; and the sectional model in iron Mr. Livesey's patent system of tramway as used in South America, of which more than 100 miles have been laid.

See also page 51.

201. TRAMWAY RAILS. Spielmann's Patent. Sectional example, actual size; and a model in wood.

Lent by Mr. John Spielmann, 16, Linden Gardens, Kensington, W. 1879.

Note.—The object gained is the possibility of changing and reversing the rails as required without interfering at all with the roadway proper.

202. TRAMWAY RAILS. A full size example in iron; Barker's Patent PERMANENT WAY for Tramways.

Lent by Mr. B. Barker, 2, Cooper Street, Manchester, 1879.

Note.—A model in wood of a street roadway laid with Barker's patent iron permanent-way for tram-cars is also exhibited together with a coloured drawing showing a sectional elevation of it. The weight of material for one mile of tramway on Mr. Barker's system is 234 tons, and its cost 950*l.*

203. TRAMWAY RAILS. One length. Mackison's Cast-iron FOUNDATION for supporting TRAMWAY RAILS: with piece of Rail, and keys for fastening.

Lent by Mr. W. Mackison, Borough Surveyor's Office, Dundee. 1879.

Note.—The specimen represents one length of permanent-way for tramways as laid in Dundee, and a coloured drawing illustrates the working detail of it and the mode of fastening it together.

ROLLING STOCK FOR TRAMWAYS.

210. WORKING MODEL. Patent Auxiliary STARTING-GEAR, for Street Tram-cars.

Lent by Mr. H. P. Holt, C.E., 4, Westminster Chambers, S.W. 1879.

211. SPRING BUFFERS, of vulcanised india-rubber; for Tram-cars. 2.

Lent by Messrs. Davis and Henwood, 28, Budge Row, E.C. 1879.

NOTE ON TRAMWAYS.

The modern tramway or street railway, consisting of iron rails of peculiar form laid in the thoroughfares of cities, and on which run cars or omnibuses drawn by horses, is of American origin. In that country tramways have been in use for some years, but in England they are of recent adoption. It may be said that not more than 15 years have elapsed since tramways were laid and their cars worked in London, the earliest of them being in the northern outskirts of the metropolis. The permanent-way, or rails for tramways, have been the subject of many patents, also the propulsion of the cars by other means than horse labour.

Steam was employed to drive a tram-car by Mr. J. L. Todd, Leith, in 1872. In 1873 a steam tramway car, on the system of the late Mr. John Grantham, of Edinburgh, engined by Messrs. Merryweather and Son, Long Acre, and built by the Oldbury Carriage Works, was tried in London in the Vauxhall Bridge Road. It has been proposed to drive tram-cars by means of powerful springs, and by compressed-air engines, in order to avoid the inconveniences experienced with the use of steam as regards the ordinary traffic of public thoroughfares in large towns and cities. Tramways of wood were laid down by Beaumont in the coal districts about 1600, and in 1738 at Whitehaven iron tramways were laid. The tramway of stone in the Commercial Road, E., was laid down by Walker 1829, and removed 1871.

CLASS II.

Agricultural Steam Engines and Machinery.

FIXED, PORTABLE, AND OTHER ENGINES.

***—At present there are no models in this group in the machinery Model collection, which contains only large drawings for lecture purposes.

1. DRAWING, Coloured. Sectional Drawing of an Agricultural Portable Engine, showing the complete detail and construction of the Boiler, Engine, and moving parts.

The drawing is lettered throughout, and needs no further description. 1878.

Note.—The well-known portable engine was first designed and constructed in 1828 by Mr. Joseph Maudslay. The name portable was adopted for these engines on account of their entire working parts with the boiler being mounted on wheels, for the purpose of transport from place to place by horses.

Traction, or self-propelling engines, now so common, were first established permanently in 1860.

2. TRACTION DYNAMOMETER. Used for ascertaining the draught of carts, waggons, and all agricultural implements which are drawn by horses. Also, for determining the resistance of roads and streets.

Lent by the Royal Agricultural Society of England. 1876.

Note.—The instrument is harnessed in the same way as a horse to the implement it is desired to test, and being itself drawn along by one or more horses it registers the total work done in passing over any given distance, the mean and extreme tractive force, the pressure on the back of the horse, and the lateral pressure in such implements as reaping and mowing machines. First used at Bedford, 1874. Designed and made for the society by its consulting engineers. *See* Journal of the Royal Agricultural Society of England, No. XX., part 2, page 678.

3. APPOLD FRICTION DYNAMOMETER.—100 Horse-power. Used for measuring the work done by steam engines and other prime movers.

Lent by the Royal Agricultural Society of England. 1876.

Note.—The prime mover to be tested is coupled to the main shaft of the dynamometer, the friction breaks of which

are loaded in proportion to the power it is desired to develop. The instrument registers the number of revolutions made in a given time, and this, together with the known weight on the breaks, furnishes the data for calculating the work done by the prime mover. This powerful instrument was constructed by the consulting engineers of the society, for the trial of steam ploughing and traction engines at Wolverhampton in 1871.

The dynamometer break for testing the power of steam engines and other machines was designed by the late Mr. John George Appold, C.E., and patented by him in 1851. Mr. Appold, about this time, also invented and patented the Centrifugal pumps, known to this day by his name, and used for engineering and drainage works in many parts of the United Kingdom and the Continent. Mr. Appold was born in 1800 and died in 1865.

Note on Traction Engines.

The traction-engine now so well-known, scarcely needs a detailed description here of its construction and principles. It may, however, be interesting to note that this class of self-propelling engine for traction purposes on ordinary roads was first seen at the Great Exhibition of 1851 in the form of a self-propelling steam cultivator from Canada, the invention of Mr. Romaine of Peterborough. In 1856 the next traction-engine appeared, Boydell's Patent, and will be remembered on account of the heavy shoes which were carried by the driving-wheels for their support in their revolution. In 1860 Mr. C. Burrell brought out the first traction-engine of the present day type. It weighed 25 tons in working order, and would draw a train of waggons equal to 18 tons weight. It should be stated that Messrs. Barran, Longstaff, and Bray, also early contributed to the construction and development of the traction-engine, which has been ameliorated from year to year, one might say, by the many well-known constructors of the present day.

Agricultural Implements and Machines.

Agricultural Implements.

5. Egyptian Plough. All wood. Beam with ox bar. Length, 11 feet 6 inches over all. Iron pointed share.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

6. JAVA PLOUGH. All wood. Iron pointed share. 13 feet long over all.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

7. CRIMEAN (RUSSIAN) THREE-FURROW PLOUGH. Wood beam and carriage. Iron shares, and coulters. Beam 6 feet, width 5 feet 6 inches over wheels, 9 feet long over all.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

Note.—This plough is now replaced in great measure by English made ploughs constructed on purpose for use in the Crimea.

8. OLD HORSE RAKE. Stubble rake. Essex pattern. 1821. 10 feet 6 inches wide, having separate shafts and wheel fore-body of wood.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

9. SUFFOLK, HORSE DRAG RAKE. All iron. This rake has been out of use 30 years. Width 10 feet 4 inches.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

10. SUFFOLK, GALLOWS PLOUGH. 1809. Wooden beam and fore-carriage. 12 feet long over all.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

11. SUFFOLK, TRUSSED BEAM PLOUGH. All wrought-iron. Known as Ransome's Y L Plough. Out of date now. Constructed 1844. Plough is 10 feet 6 inches long over all.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

12. DOUBLE FURROW PLOUGH. Constructed 1834, with double beam of wood, two iron shares, and two coulters of iron. Plough is 11 feet 6 inches long over all.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

13. PLOUGH-SHARES. Four specimens on a board. R. Ransome's patent chilled cast-iron plough-shares. 1803.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

Note.—These plough-shares of chilled cast-iron are shown precisely as they left the cast-iron mould.

14. PLOUGH-SHARES. Four specimens loose. Broken in use, or well worn.

Lent by Messrs. Ransomes, Sims, and Head, Orwell Works, Ipswich. 1879.

Note.—The foregoing series of old agricultural implements, English and foreign, were shown by the lenders at the Royal Agricultural Society's recent show at Kilburn. The English implements were all made at Ipswich 30 to 40 years ago, and are now quite obsolete.

15. MODELS of Chinese AGRICULTURAL IMPLEMENTS.

Lent by Bennet Woodcroft, Esqre., F.R.S. 1876.

Note.—These models were made by Chinese craftsmen at Shanghae, and are evidently mostly copies of European machines. They comprise a model of a chain pump to be worked by the feet. A Plough. A Harrow. Hoe, rake, &c.

A corn winnowing machine, probably made from a European model. A small mill, for grinding by millstones.

NOTE ON AGRICULTURAL IMPLEMENTS.

The earliest reaping machine seems to have been invented by James Dobbs of Birmingham, who took out a patent for the implement in 1814. Patrick Bell, a Scotch Presbyterian clergyman, about 1825, carried out entirely under his own direction, another machine, which worked for many years in Scotland. In it is devised all the principal action of the modern reaping machine. The horses are harnessed to this machine so that it may go before them and cut the corn.

The year 1852 was remarkable for the great number of patents taken out by inventors for improvements of all kinds in reaping and mowing machines. Reaping machines formed a conspicuous contribution on the part of America to the Great Exhibition of 1851, which circumstance doubtless accounts, in a great measure, for the number of patents taken out by English implement makers in 1852 for improvements in the reaping machine. Grass cutting machines, or mowers, were also exhibited in 1851 by America.

CLASS III.

Manufacturing Machinery.

SPINNING MACHINERY.

1. WORKING MODEL of a Patent SILK THROWING MACHINE.

Presented by the designer and patentee, Mr. Thomas Dickins, Edgemoor House, Higher Broughton, Manchester. 1873.

Note.—The Bobbin, Flyer, and Reel are driven by friction gear, which secures steady and certain action.

2. WORKING MODEL of a STRAND-MAKING MACHINE for Machine Cotton Rope; with a 49 Reel Frame for Cotton Yarn.

Presented by Mr. Henry Cotton. 1869.

See page 93.

3. MODEL, ⅓rd of the actual size; of a PIRN WINDING MACHINE. For making Weaver's Bobbins from Cotton Hanks.

Made and lent by Mr. Robert Hall, Hope Foundry, Bury. 1871.

4. MODEL, ⅓rd of the actual size; of a DRUM WINDING MACHINE. For making Warper's Bobbins from Cotton Hanks.

Made and lent by Mr. Robert Hall, Hope Foundry, Bury. 1871.

See also, Power Looms, p. 80.

5. WORKING MODEL of a MULE; for Spinning Cotton and other fibrous substances. (Jas. Smith's Patent, 1833.)

Lent by Bennet Woodcroft, Esqre., F.R.S. 1876.

Note.—The mule is used for spinning cotton, wool, and other yarns into fine numbers, and at the same time has a drawing-out action on the yarns, which, combined with the continuous spinning, materially increases both their strength and fineness. The mule, originally invented by Crompton at Bolton, 1774–1779, is purely a self-acting machine, and often contains more than 300 spindles in one machine, which are driven simultaneously with all the other very complicated actions of this elaborate piece of machine construction.

The modern self-acting mule driven by power was the invention of Roberts in 1825.

Weaving Machinery.

6. Models of Power Looms; for weaving. Five in number.

Lent by The Society of Arts, John Street, Adelphi. 1867.

a. Model of Power Weaving Loom by George White, Glasgow, 1830. The shuttle in this Loom is arranged with a peculiar, even-power movement, by which, for the propulsion of the shuttle, one uniform power is exerted, thereby enabling Fine Fabrics, such as Cambrics, Lawns, Jaconets, &c., to be manufactured.

b. Model of a Power Weaving Loom; showing arrangement for working a Double-shuttle Box, and other features. Designed about 1840.

c. Model of Power Weaving Loom, with Jacquard arrangement attached; for weaving and working Figured Stuffs or Pattern Stuffs. This Model shows the arrangement of the Cards in the Loom after they have been cut for the desired pattern to be worked. It further illustrates the general movement of the several parts of a Jacquard Loom.

d. Model of a Hand Loom; for weaving Sacks, Hop Pockets, &c.

This loom is designed to weave sacks or pockets without a seam either at the sides or end. Invented by T. Clulow. 1802.

e. Model of a Hand Loom designed for weaving Fishing Nets. G. Roberts, Inventor. 1802.

The above five Models of Looms; lent by The Society of Arts. 1869.

7. Model, $\frac{1}{3}$rd of the actual size; A Plain and Fancy Goods Weaving Loom, having 12-inch reed space. The Model can be driven either by hand or power.

Made and lent by Mr. Robert Hall, Spinning and Weaving Machine Maker, Bury, Lancashire. 1871.

See also, Winding Machines, page 79.

8. Model, $\frac{1}{3}$rd of the actual size; A Plain and Fancy Goods Weaving Loom, having 12-inch reed space. The Model is arranged to be driven by power. Made by Messrs. Sevill and Woolstenhulme, Machine Makers, Oldham.

Purchased. 1857.

9. MODEL of POWER LOOM, with improved Tappet Plates and Jacquard apparatus. (Woodcroft's Patent, 1838.)
Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

10. WORKING MODEL of STEAM POWER LOOM. Designed by Mr. B. Woodcroft.
Lent 1876.

Note.—This loom has a tappet motion devised by Mr. Woodcroft about 1840 for lifting the warps so as to pass the shuttle and weft, and is fitted with pendent strikers (the early method) for driving the shuttle backward and forward through the warps.

11. MODEL of a STEAM POWER LOOM.
Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

12. SECTION TAPPETS for Looms. Full-size. Bennet Woodcroft's Patent, 1843. For Weaving Plain Patterns in Stuff. Made by John Cowley and Co., Loom Makers, Ancoates, Manchester.
Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—The plates of the section tappet are parallel to each other, whereby a less amount of friction is produced against them by the treadle studs and bowls than by common plates. The jiggers which give motion to the bowls, are set out on a geometrical principle, so that the shafts rise and fall equal distances in equal times. By these means the blow of the reed is borne by each warp thread equally, whether the weft be struck home with the shed open or shut, or crossed. These tappets will weave weaker yarn than the ordinary tappet and the system is universally applied for weaving cotton, silk, linen, and woollen stuffs. They are capable of alteration and of being set to give a very large variety of patterns in weaving.

13. IMPROVED JACQUARD MACHINE. Full size. Worked by Paper Cards. (B. Woodcroft's Patent, 1838.)
Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—The improvement in this Jacquard machine consists in its being so constructed and worked as to depress some of the warp threads as much as it elevates others, whereas in the machine invented by Jacquard, and called after him, none of the warp threads were depressed, the opening for the shuttle being made by elevating some of the warp threads only. (B. Woodcroft's Patent, 1838.)

14. IMPROVED JACQUARD APPARATUS AND FITTINGS. Worked by Wooden Pegs. (B. Woodcroft's Patent, 1838.)
Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—In this improved Jacquard apparatus, those warp threads which are not raised to form the shed or opening for

the shuttle to pass through and deposit a weft thread are depressed to the same extent that the others are raised.

15. SERIES of TEMPLES; (20 in number). Various sizes.—Used in Power Looms for keeping the woven cloth stretched out in its width during manufacture. The Temples are self-acting, and are suitable for woollen, cotton, and other heavy or light fabrics.

Lent by Mr. R. Hall, Hope Foundry, Bury, Lancashire. 1871.

16. CIRCULAR KNITTING MACHINE. (J. A. Tielen's Patent, 1842.)

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note. Knitting is said to have been invented in the 16th century. The stocking-knitters of France were formed into a guild in 1527. Queen Elizabeth was presented with a pair of black silk stockings 1561. Knitted woollen stockings were first worked in England by William Ryder, 1564, and in 1577 knitting was commonly practised. The art of knitting in a frame was invented by the Rev. Mr. Lee, of Cambridge, in 1589. Cotton stockings were first made in 1730, ribbed stockings 1759. Prior to the invention of knitting, hose were made of cloth.

17. WORKING MODELS of Two Machines, driven by Steam Power; for Block Printing Tapestry Carpets and similar fabrics. Designed and Patented by Mr. Burch, 1839 to 1849.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—These two models of machines for printing carpets represent the original machines devised by Mr. Burch from 1839 to 1849, and first tried at Messrs. Crossley's works, Halifax.

Machines designed for printing fabrics and stuffs by mechanical means were first considered early in this century.

18. WORKING MODEL. The Nottingham Manufacturing Company's Patent Machine for making Fashioned Hosiery by steam power.

Lent by the Nottingham Manufacturing Company, Station Street, Nottingham. 1878.

Note.—This model represents a self-acting machine, driven by steam power, capable of making eight pieces of fashioned hosiery, or ribbed fabric stuff at one time, and of various plain colours. Four bobbins holding coloured yarns seen at the back of the machine on a frame, are required to produce each piece of stuff which, as shown, is of a single colour only. By the introduction of bobbins of various coloured yarns, striped hosiery stuff is produced. These steam power machines were brought out and patented in 1864 and 1868

for hosiery stuff, and in 1874 for the manufacture of ribbed fabrics.

19. WORKING MODEL. Machine for making Fashioned Hosiery.

Lent by the Nottingham Manufacturing Company, Station Street, Nottingham. 1878.

Note.—This model represents a hand machine for making fashioned hosiery, which was in use before the modern self-acting machine driven by steam power was brought out. This hand-power machine is capable of making one piece of hosiery stuff only at a time, and of one plain colour. The steam-driven machine, on the contrary, will produce a variety of hosiery stuffs at one operation.

NOTE ON SPINNING AND WEAVING MACHINERY.

The art of spinning fibres into thread or yarn, and afterwards weaving it into cloth or fabric, dates back to a period considerably before the Christian era. The Arcadians were taught spinning by King Arcas, 1500 B.C. In these times spinning and weaving were practised by hand labour only, women generally occupying themselves with the art of spinning, whilst men were employed in the art of weaving. To Richard Arkwright, afterwards Sir Richard Arkwright, Bart., born at Preston in 1732, and who died in 1792 with a world-wide reputation, is due the development of the science of spinning and weaving by machinery. In 1768–9 Arkwright brought out his first spinning machine for cotton fibre. In 1771 he built the first spinning mill in England, at Cromford, near Matlock, which was driven by water-power of the River Derwent; and to him and his invention of the spinning frame combined with Watts' improvements, and the effective application of the steam engine as a motive force, may be attributed the rise and prodigious developement of the cotton spinning industries. In England the spinning and weaving industries are centred in Lancashire, and in Scotland in Lanarkshire, the chief cotton cities being Manchester, Glasgow, and Liverpool. When Arkwright first arranged his spinning frames and machinery to be driven by power in lieu of the ancient distaff and whorl and of the hand spinning wheel, he employed horses.

Hargreaves, of Blackburn, invented his Spinning Jenny machine, with eight spindles running at once, in 1767. He also constructed the carding machine or engine, having revolving cylinders. The spinning-wheel was invented in Nuremburg 1530, and introduced into England 1547–1549.

The "Saw-Gin" or first cotton gin for separating the cotton wool from the pod of the cotton plant, was invented by Eli Whitney, an American, in 1793.

It should be added that in England, Manchester is the chief source of invention and production in the matter of machinery for the preparation, cleaning, spinning, and weaving of cotton; whilst for machinery used for the preparation of, and spinning and weaving coarse fibres, jute, hemp, flax, the towns of Leeds, Dundee, and Belfast are the most eminent.

Looms for weaving cloth or fabrics were used by the ancient Egyptians. The weavers' loom, called the Dutch loom, was introduced into England from Holland about 1676. In 1825 there were about 250,000 hand looms in Britain and about 75,000 looms driven by power.

The steam power loom was brought out in 1807.

Looms are divided into plain stuff looms, and figured stuff looms. The latter owe their extreme value chiefly to the inventions of Joseph Marie Jacquard of Lyons, who patented the loom called by his name in December 1801. In connection with the subject of weaving, it may be of interest to state that blankets are said to have been first made in England by Thomas Blanket at Bristol in the 14th century.

In connection with machines for spinning and weaving it may be worth while to record the recent inventions and arrangements of Mr. Binns' Oak Mills, Low Moor, near Bradford, for rendering the weaving machinery of his mill absolutely automatic. It has been stated that the machines invented by Mr. Binns when once properly arranged will run the whole night through (some 10 hours) without the slightest human attention, they the while producing both plain and figured fabrics in cotton, wool, and even silk.

MACHINE TOOLS.

20. WORKING MODEL. Photograph of original Nasmyth's Direct-Action STEAM HAMMER. Nasmyth's Patent, —1842.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—This is a photograph of the original sketch for the steam hammer made by Mr. James Nasmyth, the inventor, on 24th November 1839.

21. MODEL, WORKING.—A Single Standard STEAM HAMMER; constructed by the Exhibitors.

Lent by Messrs. B. and S. Massey, Openshaw Canal Works, Manchester. 1875.

Note.—The model is constructed on a scale of about $\frac{1}{8}$ inch to 1 foot. The steam cylinder is $3\frac{1}{2}$ inches long by $1\frac{1}{2}$ inches diameter. The hammer head or block is $1\frac{1}{2}$ by 1 inch square.

22. PHOTOGRAPHS.—Six in number; of STEAM HAMMERS, and Iron Working Machines.

Presented by Messrs. Thwaites and Carbutt, Engineers, Vulcan Iron Works, Bradford. 1869.

1. Photograph of a Duplex Horizontal Steam Hammer.
2. Photograph of a Bossing Steam Hammer, 12 cwt.
3. Photograph of a 25-cwt., Double frame, Single Standard Steam Hammer.
4. Photograph of a Rail Straightening and Shearing Machine.
5. Photograph of a 40-cwt. Double-action Steam Hammer.
6. Photograph of a 10-ton Single-action Steam Hammer.

23. LITHOGRAPHS.—Two in number, of STEAM HAMMERS.

Presented by Messrs. Thwaites and Carbutt, Engineers, Vulcan Iron Works, Bradford. 1869.

1. Lithograph of a 12-cwt. Improved Tilt Hammer.
2. Lithograph of 10-ton Double-action Steam Hammer.

24. PHOTOGRAPH.—Three Cylinder High-pressure Steam Engine, coupled to a Circular Saw, for cutting Metals.—P. Brotherhood's patent.

Presented by Messrs. Brotherhood and Hardingham, Patentees and Engineers, London, E.C. 1874.

25. PHOTOGRAPH. Three Cylinder HIGH-PRESSURE STEAM ENGINE, attached to a Circular Saw with Traversing Movement, for cutting Metals.—P. Brotherhood's patent.

Presented by Messrs. Brotherhood and Hardingham, Engineers, London, E.C. 1874.

See also pages 12, 59, 108.

26. McKAY'S Patent Equilibrium DRILLING TOOLS. Specimens of Work.

Lent by Messrs. Menzies and Blagburn, Engineers, Newcastle-on-Tyne. 1876.

Note.—This apparatus is designed to permit circular holes of any size to be bored out with mathematical accuracy and absolute precision as to their relative positions.

This object is attained by maintaining the centre point, around which the cutters revolve, immovably fixed during the process of boring, while the cutters are advanced, and are held in equilibrium with the centre points by a hydraulic medium contained within the chambers of the tool, the pressure being conveyed by the action of the feed given to the boring machine.

This apparatus is exhibited for the purpose of showing how accurate work can be obtained with a minimum of skilled labour and cost.

27. MODEL. Machine for Rolling Bars of Metal; for Bolts, etc. Designed by Sir Robert Seppings, 1829.
1864.

Note.—This machine will be found in Ship Model Collection.

28. MODEL of an Improved Method of REVERSING IRON ROLLING-MILLS.

Lent by Mr. Jeremiah Head, M. Inst. C.E., Middlesborough. 1876.

Note.—A separate piece is introduced between the clutch and each clutch wheel, and connected with the latter only by elastic arms. The shock which ordinarily takes place when the clutch is thrown into gear is thus prevented.

This model is constructed by R. Richardson, 9, Sussex Street, Middlesborough.

29. Two Smooth-boring AUGER BITS. Recommended by the late Mr. Joseph Tucker, joint surveyor of H.M. Navy from 1813 to 1831, for the reduction of decay in wooden ships.

Presented by Mr. J. S. Tucker. 1865.

Note.—These are in the Ship Model Collection.

NOTE ON MACHINE TOOLS.

Machines of large size and great power for working by mechanical means iron and metal, are now universally employed. In connection with them and their invention and improvements for the purposes of smoothing, planing, turning, boring, and many other operations performed in the working of iron and metals at the present day, perhaps the names of the English mechanical engineers Sir Joseph Whitworth, Bart., Manchester, and the late Sir William Fairbairn, Bart., Manchester, stand pre-eminent.

WOOD WORKING MACHINES.

30. DOVETAILING MACHINE for Wood-working. Hand machine. Designed and patented in 1874, by the exhibitor.

Lent by Mr. W. Tighe Hamilton, Ham Villa, Rathmines, Dublin. 1876.

Note.—This machine is a full size machine, worked by the hand and foot. It is in form somewhat like an ordinary turning lathe, and cuts the tails and pins for dovetailing purposes by means of vibrating circular saws. These saws are given a vibrating or wobbling motion, by an eccentric

disc of peculiar construction, acting on a horizontal shaft from a fixed radius. The saws set for tail and pin cutting require to be interchanged, and the headstock of the machine canted up vertically, so as to throw the eccentric motion into the right position when the machine is to be used for pin cutting. Powerful machines for dovetail and pin cutting to be driven by steam power have also been arranged by Mr. W. Tighe Hamilton.

Note.—Machines for carving wood, on the Pentagraph system, and driven by steam power, designed to reproduce several copies of the original object at one operation, were patented in 1845 by Thomas B. Jordan, and have since been extensively used. Jordan's machines were used for the production of the ornamental carved wood work, bosses, panels, frames, and the like, used in the present Houses of Parliament.

31. DRAWINGS COLOURED. Eleven in number. English and Foreign Wood Working Machinery; with details.

Prepared by Professor Exner of Vienna; for lecture purposes in the High School of Forestry at Vienna.

Presented 1877.

Note.—These coloured drawings represent on a large scale for lecture purposes the wood working machines and their details of the English manufacturers Messrs. A. Ransome and Co., Robinson and Co., Worssam and Co., and others. Also the machines by the foreign makers Zimmermann, Chemnitz; S. A. Woods, Boston, U.S.A.; Kelley, Philadelphia, U.S.A.; R. Ball, Worcester, Mass., U.S.A.; Hartman, Chemnitz; F. Arbey, Paris; and Système, Elenberg.

The drawings relate principally to the detail of planing machines, and represent the cutting tools and feed apparatus, carriages, &c. used in vertical and horizontal planing machines.

NOTE ON WOOD-WORKING MACHINERY.

Implements for cutting and working wood are of prehistoric date. The axe is the earliest known implement for wood cutting. The saw seems to have been invented, according to a statement of Pliny, by one Daedalus, an Athenian, B.C. 1,000; and, according to Apolodorus, by Talmus, who used the jaw-bone of a snake to cut through a piece of wood, and afterwards made saws of iron like it. The plane and chisel would appear to be of much later date than the invention of the axe and saw.

Saw-mills, *i.e.*, mills driven by external power for sawing timber, were first set up at Madeira in 1420. At Breslau saw-mills were in use in 1427. Norway had a saw-mill at work in 1530. The Bishop of Ely, sent by Queen Mary of

England in 1555 as Ambassador to Rome, describes a saw-mill which he there saw at work.

The first saw-mill in England was erected by a Dutchman in 1663; and saw-mills were first set up near London about 1770. These saw-mills were chiefly driven by wind or water power. The former plan is much in vogue in Holland to this day.

Saw-mills worked by steam-power were started in the very early part of this century. The steam saw-mills at Woolwich and Chatham Dockyards, erected from the designs of Sir Marc Isambard Brunel, and invented by him, were set up 1806–1813, and the celebrated ship's block-making machinery at Portsmouth Dockyard, also invented by him, was erected in 1804 by Maudslay & Sons, Engineers, Westminster Bridge Road.

The endless band-saw now used for sawing timber and cutting ornamental perforated patterns in wood, was brought out in England in 1858. It was originally designed by M. Perrin, at Paris.

Great strides have been made of late years in the construction of machines driven by steam-power for working wood. Almost any of the operations of the carpenter's and joiner's craft are executed by machinery. The cooper and wheelwright are also much assisted and replaced by machinery constructed on purpose to carry out their handiwork. The latest piece of mechanism in wood-working machines trenches upon the craft of the woodman. It consists of a portable machine for felling trees, comprising a horizontal saw driven by steam-power. It is the invention of Messrs. A. Ransome and Co. of Chelsea.

In connexion with wood working machinery may be mentioned the modern wood paving now laid in the principal streets and thoroughfares of the metropolis, the wood blocks for which are all cut by steam machinery. The present system of wood paving was first laid in London about 1872. Many different plans of execution have been tried, the most recent being as follows: the wood blocks rest edgeways or grain upwards upon a solid bed of concrete laid in two layers, coarse below, fine at the top; the wood blocks are laid in diagonal courses similar to brickwork across the thoroughfare, separated from each other about one inch. The whole is then grouted with Portland cement and fine sand, and the roadway is completed for traffic.

PAPER-MAKING MACHINERY.

32. DRAWING of Patent Machinery for the chemical preparation of Pulp from Wood, Straw, and Fibrous Material, for the Manufacture of PAPER of all kinds and qualities. Sinclair's system.

The Machinery designed and arranged by Mr. J. McNicol, C.E., 97, Buchanan Street, Glasgow, and the drawing lent by him. 1874.

Note.—The drawing represents the following portions of the patent machinery by W. Sinclair, for paper manufacture On a ½ inch to 1 foot scale :—

Fig. 1. Longitudinal through section of Sinclair's patent high-pressure tubular steam boiler.

Fig. 2. Front or firing end elevation of Sinclair's high-pressure tubular steam boiler.

Fig. 3. Sectional elevation of wood pulp boiler.

Fig. 4. End elevation of blow-off pulp receiving tank.

Fig. 5. General plan of apparatus.

Fig. 6. Front and side elevation of wood-chopping machine.

Fig. 7. On a Scale of ¼ inch to 1 foot. The soda ash (used to dissolve the wood into pulp) recovery apparatus. A longitudinal and cross section of the apparatus.

Fig. 8. To full size. The Sinclair patent conical plug joint for high-pressure steam boiler tubes.

Fig. 9. To full size. The section of a hollow conical boiler tube joint. Sinclair's system.

Note on Paper making.

Paper was probably first made in Egypt considerably before the Christian era. It was made of cotton about A.D. 600; and of rags about 13 A.D. White coarse paper was first made in England, at Dartford in Kent, by John Speilman, a German, in Queen Elizabeth's reign, 1580 ; and at Dartford the first paper mills were erected.

Writing and printing paper were first made in England in the reign of William III., 1690, before which date these papers were imported from Holland and France.

Machine paper-making was first suggested by Louis Robert, a Frenchman. He sold his invention to Didot, the great French printer, who brought the machine to England, and in conjunction with Fourdrinier perfected Robert's invention. Fourdrinier took out the earliest patent for paper-making machinery in 1801; and for manufacturing paper of indefinite length in 1807.

Paper is now made of straw, grass, wood, and other fibrous substances. Spanish or Esparto grass was first imported for paper-making in 1857. In 1866 wood pulp for paper was first used in America. Hop-stalks were used in France in 1873.

Hide and Leather Machinery.

Note.—This group is not yet represented by any models, Very much has been done however of late in devising

machines for use in tanneries and leather dressing factories, some account of which was given in the British Trade Journal for April 1877.

But see Craftsmen's Hand Tools. Page 102.

NOTE ON TANNING.

The tanning of leather with the bark of trees is of early date. The art was first brought to England from Holland by William III. in 1689. Bark of orange trees was then used. In 1719 Bananas were employed. The science of chemistry has of late years done much for the present methods and processes used in tanning.

See Craftsmen's Hand Tools. Page 102.

NOTE ON BLEACHING.

According to Pliny, the Roman philosopher, (born A.D. 23, died A.D. 79,) the art of bleaching was known in Egypt, Syria, India, and Gaul. Chemical bleaching was introduced into England by the Dutch, 1768. Bleach fields were established in Lancashire, Fife, Forfar, Renfrew, and in the Vale of Leven, Dumbartonshire.

Chlorine gas was applied to bleaching after Berthollet's discovery in 1785. Mr. Tennant of Glasgow combined chlorine gas with lime (as chloride of lime) in 1798, and this substance is still largely manufactured and used for bleaching purposes.

NOTE ON DYEING FABRICS AND STUFFS.

The art of dyeing is attributed to the Tyrians, B.C. 1540. The English sent their goods to Holland to be dyed until 1608, when the art of dyeing was established in this country. Chemical knowledge and research have vastly improved and multiplied the processes and practice of dyeing. The celebrated dye colour Mauve produced from lichens was due to a discovery by Dr. Stenhouse in 1848, afterwards perfected by M. Marnas. Dr. Hoffmann produced in 1861–1863 the dye colour Aniline from coal tar. This has since led to the production of many of the present superb colours employed in dyeing. Aniline was first discovered, it is said, by Bechamp in 1856.

NOTE ON FULLING.

The process of fulling cloth by means of fuller's-earth, an earthy hydrated silicate of aluminium, containing silica, alumina, ferric oxide, magnesia, sodium-chloride, potash,

and water, is of very great antiquity. Fulling cloth was known to the ancient Egyptians, Greeks, and Romans, and representations of the fuller's craft are to be found on ancient monuments, notably at Pompeii. The machinery employed for fulling, that is, for removing from cloth the oil and grease left in it during manufacture, was anciently of wood only. This old wooden machinery was improved upon in 1825 by Ogle, who employed iron in lieu of wood to form the stand and bed of the stocks, and a steam vessel under the bed, to heat the cloth during the operation of fulling. In Ogle's improved stocks the beaters were capable of adjustment to suit different qualities of cloth, and the iron bed was faced up and polished so as to form a perfectly smooth surface, an immense improvement on the old rough wooden apparatus. Fuller's-earth is found at Nutfield near Reigate, Renton in Yorkshire, Quarry Wood in Morayshire, Maidstone in Kent, and in Saxony and Bohemia. It was also largely mined in the Down, near Bath, for use in the cloth mills of Bradford-on-Avon, Frome, Somersetshire, and those of Gloucestershire. The employment of fuller's-earth for cleansing cloth has become almost superseded by the use of chemicals. The modern term for fulling cloth is "milling," and according to the number of times the cloth is fulled or milled, it is said to be double-milled or treble-milled. The machinery now employed in felting and milling is elaborate and complex.

Note on Wool Machinery.

Fabrics of wool were known in Palestine, Syria, Greece, Italy, Spain, and Asia before the Christian Era. Sheep washing may be said to begin the preparation of wool for manufacture. To St. Blaise, an Armenian bishop 289 A.D., the art of wool combing is attributed. The following are the operations through which the wool passes in preparation for cloth-making:—sorting, scouring, dyeing, deviling, picking, oiling, scribbling, carding, slubbing, drawing, and spinning; after which follow spooling, weaving, fulling or milling, teazeling, shearing, pressing and brushing. Steam-power machinery is chiefly used for these processes but skilled hand-labour is employed for making flannel, pile carpets, and fine fabrics.

Note on Silk Machinery.

The Chinese are known to have cultivated the silk-worm and silk 1700 B.C. Aristotle, the Greek philosopher 384–322 B.C., is the first western writer who mentions silk. In 1717 John Lombe set up at Derby silk works from models of a silk-throwing mill in Sardinia, and his family permanently established its manufacture. In the preparation of silk the

processes are steeping the cocoons in warm water to separate the silken filaments which are carried round a reel and wound into skeins. Skeins are made up into hanks forming "raw silk," which are wound on to frames called swifts, and then transferred to bobbins; after which the processes are clearing, spinning, doubling, throwing, glossing, winding, and weaving. 250 cocoons weigh about one pound, and 12 pound of cocoons yield one pound of silk. The quality of silk is denoted by the number of yards to the "denïer" a weight equal to 24 grains. Floss silk obtained from the outer portion of the cocoon is worked into yarn for cheap silk fabric by the processes of sorting, hackling, filling-engine, cutting, drawing, scutching, washing, boiling, drying, carding, made into slivers, doubling and drawing, roveing, spinning.

Note on Flax Machinery.

Flax, a vegetable fibre, was cultivated by the ancient Egyptians, Greeks, Romans, Tyrians, and by other nations. The flax plant yielding also linseed was grown in England 1189 A.D. and in Scotland 1210 A.D. Egypt, Russia, France, and Belgium are the principal flax producing countries. The processes to which the plant and its fibre are submitted in preparation for the manufacture of linen are the following; steeping or retting, drying, breaking, scutching, sorting, hackling, spinning into yarn, weaving into linen cloth, and finally bleaching.

Hemp, the vegetable fibre used principally for rope and cordage, grows chiefly in Scythia. The ancient Greeks and Romans used ropes made of it. Herodotus, the Greek historian B.C. 484–408, first mentions hemp, and says that the Thracians made garments of it resembling linen. The hemp plant producing also hemp seed, in preparation for the manufacture of yarn and rope, goes through the steeping or retting process, and is afterwards treated in a manner similar to flax.

Note on Jute Machinery.

The Indian vegetable fibre jute is used for making gunny-bags, matting, rope, and other coarse fabrics. In its manufacture jute is sprinkled with oil and water, spread out for a day or two, and then passed through rollers to render it soft and pliable. It is next passed through fluted rollers, arranging the fibre into a kind of sliver, which is again passed between finer fluted rollers. These machines are called the breaker-card and the finisher-card. The slivers are afterwards passed to the drawing-frame, similar in its operation to that employed in cotton manufacture. The sliver is next slightly twisted, wound upon bobbins by the roving-machine, and spun by a throstle. The finished yarn for warps is wound

on to bobbins by the winding-machine, and transferred to the loom beam by the beaming-machine. The yarns for wefts are wound on to the pirns of the shuttles by the pirning-machine. The finest jute yarns bear the lowest numbers ; in cotton yarn the reverse is the case. The jute-loom and shuttle are larger and stronger than those employed for weaving cotton and wool. Jute twine is sized, it is stated, with glue water, starch, tallow, and china clay.

NOTE ON ROPE-MAKING MACHINES.

Rope, a general name applied to cordage or spun yarns over one inch in circumference. Ropes are made of hemp, flax, cotton, coir, or wire of metal. Rope was made of various materials by the ancient Egyptians, especially of papyrus and of leather. In a tomb at Thebes, of the period of Thothmes III., the Pharoah of Exodus, is an illustration representing ancient Egyptian workmen employed in the process of making rope of thongs of leather. The ancient Greeks and Romans made rope of the tendons of animals, and used them for their war engines.

Rope-making machines were invented in England in 1783–4 by Sylvester, also by Richard March about the same time, and by Edmund Cartwright in 1792. Flat-rope making was patented by Messrs. Chapman 1807. Rope made of metal wire was first used for mining purposes in 1831.

Manufactured rope is technically known as hawser-laid and cable-laid rope, according to the number of yarns and strands employed to produce it, and the direction in which they are twisted or laid to form it. Cable-laid rope is heavier than hawser-laid rope, 30 fathoms of the yarn employed in making it being reckoned equivalent in length to 18 fathoms of cable-laid rope, whilst the same quantity of yarn is reckoned to produce 20 fathoms of hawser-laid rope.

At Chatham Dockyard there is a celebrated mill for making ships' rope and cordage by steam machinery, erected early in the present century. Huddart 1800, Thompson 1801, and Belfour 1793–1798, appear, with others, to have successfully invented improvements in machinery for spinning rope-yarns, tarring, and the final laying and making of rope and cordage.

See No. 2, Class III., page 79.

Craftsmen's Hand Tools.

The axe is the oldest existing cutting tool known, and saws follow next in antiquity. The plane and chisel are of much later date. It may be recorded that knives of steel were first made in England in Hallamshire, the district about Sheffield, by Richard Mathews 1563; and clasp or spring knives introduced from Flanders became common in 1650. Table forks of metal were made on the continent in the 13th and 14th centuries, particularly in Italy, whence they were brought by Thomas Coryate in 1608 and introduced into England. Forks of silver were in general use in 1814.

35. CRAFTSMEN'S HAND TOOLS. — ENGLISH MANUFACTURE.

1. AXES. For Woodmen, Carpenters, Wheelwrights, Shipwrights, Coachmakers, Coopers, Butchers, &c.

2. ADZES. For Carpenters, Wheelwrights, Shipwrights, Coopers. Chairmakers' Howels.

3. HAMMERS. For Bricklayers, Plasterers, Masons, Slaters, Plumbers, Carpenters, Coopers, Coachmakers, Shipwrights, Grocers, Shoemakers, Farriers, &c.
Engineers' Hammers.
Boilermakers' Hammers.
Nailmakers' Hammers.
Quarrymen and Miners' Tools.

4. TROWELS. For Bricklayers, Plasterers, and Masons.

5. CHISELS and GOUGES. For Carpenters, Joiners, Coachmakers, Patternmakers, Cabinetmakers, &c.
Millwrights' Chisels and Gouges.
Chisels and Gouges for Turners.
Firmer Chisels and Gouges.
Socket Chisels and Gouges.
Shipwrights' Chisels and Caulking Irons.

6. AUGERS, DOWELLING BITS, &c. For Carpenters, Shipwrights, Wheelwrights, Coachmakers, &c.
Patent Screw Bits.
Screw Augers.
Shell Augers.
Ship Augers.

7. CHOPPERS and CLEAVERS. For Butchers and Meat Salesmen, &c.

Choppers of London, Devon, York, Nottingham, and Ireland patterns.

Sugar Choppers.

8. KNIVES. For Butchers, Cheesemongers, Buttermen, and Porkmen.

Cheese Tasters.

Butter Borers.

Sugar Borers.

Matchets or Cutlasses.

Sugar-cane Bills.

Cotton Plant Pruning Hooks.

Sugar-cane Knives.

HAY AND CHAFF CUTTING KNIVES.

9. SHEARS. For Coppersmiths, Tinmen, Zinc Workers, &c.

10. GARDEN TOOLS. Grass Border Shears, Lopping Shears. Spuds, Hoes, Rakes, Forks and Spades, Scythes, &c. Bedding and Potting Tools.

11. FARM TOOLS. Broom Hooks and Bill Hooks. Switching Bills or Slashers. Brushing or Hedge Hooks. Reaping Hooks, Grass Hooks.

Forks.—Digging, Manure, Potatoe, and Hay Forks.

Scythes.

12. MISCELLANEOUS ARTICLES. Railway Platelayers' Tools. Blacksmiths' Pincers. Plumbers' Scrapers. Lath Renders. Cart-arms and Boxes. Wheel Boxing Machine. Lifting Jack. Vices, Cramps, &c.

36. A Collection of HAND TOOLS; used by Curriers, Tanners, and Leather Workers.

Presented by Mr. James Toleman, 80, Bermondsey Street, Bermondsey. 1879.

Note.—For details of this collection see page 102.

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37. COLLECTION OF CRAFTSMEN'S HAND TOOLS.— FRENCH MANUFACTURE.

HAND TOOLS made by Messrs. Gautier and Baillet, Rue Lamartine, Paris, 1867. Purchased. 1868.

The Collection comprises the following HAND TOOLS:—

Carpenters' and Joiners' tools. Planing Irons. Ploughs. Hollow Planes. Rounding Planes. Moulding Planes. Mitre-block. Mitre-shoot. Mitre-chisels. Small Turning Lathe and Fittings. Bows and Drills. Bevel and Square

Metal Spirit Levels. Iron Square, &c. *Gautier and Baillet, Paris.* 1868.

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38. COLLECTION OF CRAFTSMEN'S TOOLS.— FROM THE PRESIDENCY OF BOMBAY, INDIA.

Presented. 1871.

Used in the manufacture of "Bombay" Inlaid work.

The Collection comprises the following TOOLS:—

Stock and Drill, and set of Bits.

Saws, Files, Hammers, Chisels, Planes. Mitre-Block. Compasses. Square and Gauge in Wood.

Wooden Clamp. Glue Pot and Brush. Whetting Stones. Wood Blocks for Stamping Mouldings.

Specimens of inlaid work; finished and in progress. *Bombay India.* 1871.

Note.—These objects were received from the London International Exhibition, 1871.

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39. COLLECTION OF CRAFTSMEN'S HAND TOOLS.— AUSTRIAN MANUFACTURE.

HAND TOOLS made by Baron Wertheim and Co., Vienna, 1868.

Purchased. 1868.

The Collection comprises the following HAND TOOLS:—

Carpenters', Cabinetmakers', Joiners', Coachmakers', Wheelwrights', and Coopers' Tools. *Wertheim, Vienna.* *1868.*

Hand Planes. 26 Planes in Black Wood, Circular Planes, Ploughs, &c. *Wertheim, Vienna.* *1868.*

Hand Planes and Trying Planes. 11 Hand Planes and 1 Trying Plane in Yellow Wood. *Wertheim, Vienna.* *1868.*

Hand Planes, in Rose Wood. Trying Plane, 5 Moulding Planes, 4 Rabbet Planes, Ploughs, Side-Filisters, Sash-Filister, 5 Hand Planes, 5 Moulding Planes for Circular Work. *Wertheim, Vienna.* *1868.*

Hand Planes, in White Wood (Birch), 74. Moulding Planes. Beads, Hollows and Rounds, O.G. Mould-

ings, Rabbet Planes, Sash Planes, Ploughs, Filisters, and Grooving Planes. *Wertheim, Vienna.* *1868.*

Hand Planes, in White Wood, 46. Trying Planes. Jack Planes. Hand Planes. Moulding Planes. Circular Planes. Smoothing Planes. Hollow Planes. Ploughs. Filisters, &c. *Wertheim, Vienna.* *1868.*

HAND TOOLS, FOR COOPERS. *Austrian. Wertheim, Vienna, 1868.* Jointing Plane, Taper Bit. Rimeing Bit, for cutting Bungholes. Plane for Hoop Cutting. Ploughs for Circular Work. Angle Rebate Plane, and Side Rebate Plane. Circular Planes with Iron Gauges. Routers. Wood Screw Vice.

SAWS. Austrian. *Wertheim, Vienna, 1868.* Double Saw. Six Frame Saws. Framed Saw and Mitre Cutting Block. Framed Saw and Block, for Cutting any Angle.

HAND TOOLS, Miscellaneous. *Austrian. Wertheim. Vienna, 1868.* Double and Single Hand Screws. Clamps. Wood Squares. Reed Planes. Small Chariot Planes.

HAND TOOLS, Miscellaneous. *Austrian. Wertheim, Vienna, 1868.* Cabbage Slicing Machine, with 5 blades. Cucumber Slicing Machine, &c.

WOOD BLOCKS. *Austrian. Wertheim, Vienna, 1868.* Fitted for Coppersmiths, Brassworkers, Tinmen, Zinc, Iron, and Lead Workers' use.

TURNING LATHE, in Wood. *Austrian. Wertheim, Vienna, 1868.* Fitted with Reciprocating Saw, Moveable Head Stock, Sliding Seat. Driving Wheel, and Treadle.

BENCH for Carpenters or Cabinetmakers. *Austrian. Wertheim Vienna, 1868.* 4 feet 3 inches long by 2 feet wide. Fitted with Screw Block, Wood Vice, Hand Screws, &c.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 1. Wall Case.—Hammers.
For Carpenters, Cabinetmakers, Joiners, Engineers, &c.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 2. Wall Case.—Curriers' Tools.
Knives, Scrapers, &c.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 3. Wall Case.—Carpenters' Tools.
Gimlets, Augers, Gouges, Spanners, Punches, Squares, &c.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 4. Wall Case.—Engineers' Tools.
Shears, Callipers, Compasses, Pincers, &c.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 5. Wall Case.—Turners' Tools.
Chisels, Gouges, &c. for Wood; Chisels, and Cutters for Iron work.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 6. Wall Case.—Turner's Tools.
Chisels and Gouges for Wood Turning, Iron and Metal Turning.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 7. Wall Case.—Carpenters' and Cabinet-makers' Tools.
Firmer Chisels.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 8. Wall Case.—Carpenters' and Cabinet-makers' Tools.
Single and Double Plane Irons, Toothing Irons for Veneer Work.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 9. Wall Case.—Curriers' and Smiths' Tools.
Knives for Curriers' Work. Moulds, Punches, &c., for Smiths' Work.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 10. Wall Case.—Engineers' and Smiths' Tools.
Stocks and Dies, Braces, Hand Vices, Plane Irons, &c.
Machine for Cutting Cavendish Tobacco.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 11. Wall Case.—Coachmakers' Tools.
Plough and Rebate Planes, Stocks and Dies, Braces, Metal Gauge, Plumb Bob and Level, &c.

HAND TOOLS. Austrian. Wertheim, Vienna, 1869.
No. 12. Wall Case. — Carpenters' and Wheelwrights' Tools.
Drawing Knives, Spoke Shaves, Compasses, Saw Setts, Bevels, Gauges, Hand Vices, &c.

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40. OLD GERMAN FANCY TURNING LATHE.—
Probably for Watch and Clockmaker's use.
Purchased. 1872.

41. OLD GERMAN CLOCKWORK.—
Probably the Striking or Chiming part of a Clock.
Purchased. 1872.

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42. COLLECTION OF CRAFTSMEN'S HAND TOOLS FROM CHINA.

Presented. 1874.

The collection illustrates TOOLS used by Bricklayers and Masons; comprising the following:—Trowels, Mortar-hod, Mallet. Specimens of Scaffolding and Scaffold Cords. Whitewash Brush. Wedges, Chisels and Drills. Cane Baskets for carrying materials. *Chinese.* *1874.*

43. TOOLS used by Chinese Carpenters and Painters:—
The collection comprises Planes; Smoothing, Moulding and Long Planes. Drills and Bradawls. Chisels and Gouges. Frame Saw. Hand Saw. Axes. Plumb and Bob Line. Marking Line. Wooden Square. Compasses. Model of a Turning Lathe. *Chinese.* *1874.*

Note.—These tools were exhibited at the London International Exhibition of 1874, and presented to the Museum at its close.

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44. COLLECTION of CRAFTSMENS' HAND TOOLS and HARDWARE.—CHINESE MANUFACTURE.

Presented. 1875.
From the London International Exhibition, 1874.

The Collection contains the following objects:—

AXES.—Mason's and Carpenter's Chisels. Gouges. Plane Irons. Auger Bits. Drawing Knife. Saw Blades.—*Chinese.* *1875.*

CHOPPERS AND CLEAVERS.—Fish and Meat Choppers. Bone Chopper. Kitchen Cleavers. Choppers for Wood. Fire-wood Chopper.—*Chinese.* *1875.*

KNIVES. — Fish and Meat Salesmen's Knives. Pork Butchers' Knives. Fruit Sellers' Knives. Bookbinder's Knife. Clothworker's Knife. Shoemaker's Knife. Brazier's Knife. Gardeners' Knives. Bamboo Cutting Knife. Pocket Knives, various. Toe and Finger Nail Dressing Knives. Sailors' Knives. Table Knives. Chop Sticks.—*Chinese.* *1875.*

RAZORS.—Ordinary Shaving Razors. Pocket Shaving Razors. Antiquated Razor.—*Chinese.* *1875.*

SCISSORS. — Stable Scissors. Tailors' Scissors. Tinman's and Smith's Tongs and Scissors. Gardener's Scissors. Opium-cutting Scissors. Ordinary household Scissors.—*Chinese.* *1875.*

AGRICULTURAL TOOLS.—Sickles. Hoes. Spuds, &c. *Chinese.* *1875.*

FORESTRY TOOLS. Wood-wards' Bills. Axes. Draw-shaves. Brushing, Topping, and Lopping Hooks, &c.—*Chinese.* *1875.*

ENGRAVER'S TOOLS.—A set of six.—*Chinese.* *1875.*

GRAVING TOOLS.—A set of 24.—*Chinese.* *1875.*

STEEL PUNCH for testing Dollars.—*Chinese.* *1875.*

OPIUM PIPE FILLER AND CLEANER.—*Chinese.* *1875.*

PAIR OF PINCERS used for plucking Geese.—*Chinese.* *1875.*

RICE COOKING SHOVEL.—*Chinese.* *1875.*

SUGAR CANE PEELER.—*Chinese.* *1875.*

BETEL NUT CUTTER.—*Chinese.* *1875.*

EXECUTIONERS' KNIVES.—*Chinese.* *1875.*

MILITARY SWORDS. — Officer's Sword. Soldier's Single Sword and Double Sword.—*Chinese.* *1875.*

PAIR OF CRUCIBLES for manufacturing steel.—*Chinese.* *1875.*

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45. COLLECTION OF CRAFTSMEN'S HAND TOOLS FROM JAPAN.

Purchased. 1868.

The collection comprises the following TOOLS used by Japanese Carpenters and Cabinetmakers.— Saws. Planes.

Axe. Wooden Mallet. Chisels. Gouges. Files. Bradawls. Screwdriver. Pincers. Square in Steel. *Japanese.* *1868.*

Note.—Purchased at the Paris Universal Exhibition, 1867.

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46. COLLECTION OF CRAFTSMEN'S HAND TOOLS FROM JAPAN.

Presented by the Japanese Commissioner to the London International Exhibition, 1874.

The collection comprises—

TOOLS used by Enamellers on Metal. Specimens of the Colours employed, and pieces of work. *Japanese.* *1874.*

TROWELS, Japanese Tools; for Bricklayers', Plasterers', and Masons' use, 54 in number. Various sizes and shapes. Specimens of ornamental Plaster work, by Japanese craftsmen. *Japanese.* *1874.*

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47. COLLECTION OF HAND TOOLS FROM BORNEO.

Presented. 1875.

From the London International Exhibition of 1874.

KNIVES. — "Chandong."—Knife used for wood-cutting, or as a fighting weapon.—*Borneo.* *1875.*

Native Knives of sorts.—*Borneo.* *1875.*

Knife for cutting Rattan.—*Borneo.* *1875.*

Knife used for Boring holes.—*Borneo.* *1875.*

Nut Cutters; used for cutting and splitting Betel Nut.—*Borneo.* *1875.*

RAZORS.—Native Razors. (2.)—*Borneo.* *1875.*

SCISSORS.—Pair of Native Scissors.—*Borneo.* *1875.*

"GOLOK," or Native Dagger.—*Borneo.* *1875.*

SPEAR HEAD.—*Borneo.* *1875.*

"BALIYUNG."—Implement used for cutting and smoothing timber. (The cutting tool is wanting.) —*Borneo.* *1875.*

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48. COLLECTION OF AGRICULTURAL HAND TOOLS.

Presented. 1875.

From the London International Exhibition of 1874.

a. "Udella." A hoe used in preparing clay soil for cultivation. Oval shape. *1875.*

b. "Udella." A hoe used in preparing clay soil for cultivation. Square shape. *1875.*

c. "Porowa." An axe. *1875.*

d. "Manne." A chopper used for chopping Cocoa Nut flowers preparatory to yielding toddy. *1875.*

e. Household Choppers. *1875.*

f. Bill Hook. *1875.*

g. "Hiwela." A ploughshare, of wood. Tipped with iron. Two shares of iron. *1875.*

CRAFTSMEN'S TOOLS AND GEAR.

50. SET of Weston's Patent Differential PULLEY BLOCKS, 1859. For engineers, stonemasons, and other craftsmen's use. Messrs. S. & E. Ransome, Essex Street, Strand.

Lent 1871.

Note.—These patent pulley blocks were patented 1859 by Mr. Weston. They are called "differential" on account of the sheaves of the standing block, which are cast together, being of unequal diameters.

The hoisting chain is rove over them and round the fall in a crosswise manner so that the fall is always in equilibrium, and consequently will not move or slip either way without hauling upon the leading ends of the chain. The block sheaves are grooved and notched to fit the links of the chain employed.

51. Tanners' and Curriers' HAND TOOLS.

Presented by Mr. James Toleman, Hide and Leather-workers' Tool Maker, 80, Bermondsey Street, Bermondsey. 1879.

Note.—The following hand tools used by craftsmen in the preparation and manufacture of leather will be found in this collection. Tanners' working, fleshing, and rounding knives. Striking pins, hooks, tongs, shovels, forks, &c. Curriers knives, steels, pummice, &c. Skinners' moon knives, parchment knives, and boxes. Brass, copper, steel, and glas buffing and diceing sleakers. Scotch, Irish, Welsh, Kendal, and other stones. Scudding slates, brushes, graining boards,

cork and india-rubber. Lignum-vitæ and glass beam boards, spring boards, boxwood and lignum-vitæ rollers. Brass and steel graining rollers, straining hammers, French crippler or arm-board, butt rollers, &c.

52. SCREWING STOCK. Model in steel. Everitt's Patent CAM FEED Screw STOCK. Hand-machine for cutting screws. J. Cowley and Son, makers, Walsall.

Lent by Mr. R. Edwards, Bury Road, Thetford. 1879

SUGAR-MILL MACHINERY.

55. SUGAR MILL; Sugar-cane CRUSHING MILL, small size. Fitted upon Roussellot's system for the bearings and journals of the rollers.

Lent by Messrs. Fawcett, Preston, and Co., Engineers, Liverpool. 1879.

Note.—M. Roussellot's patented method of fitting and arranging the bearings and journals for the crushing rollers of sugar-cane mills consists in affording a means of removing the rollers for repair and overhaul without dismounting the mill. It is accomplished by an arrangement of adjustable wrought-iron bolts and nuts, which effectually keep in place the plummer blocks or bearings of the rollers, and afford a means of adjusting them from time to time, or of a ready entire removal of the rollers from the mill.

See also page 146.

CLASS IV.

Hydraulic and Pneumatic Machinery.

PUMPS, STEAM AND OTHER.

1. WORKING MODEL. Cope and Maxwell's Self-Governing Steam Pump.

Lent by Messrs. Hayward Tyler, and Co., 84, Whitecross Street, E.C. 1877.

Note.—This form of pump is unlike in its arrangement other direct-acting steam pumps. The valve motion, invented by Cope and Maxwell, is derived by mechanical means from the main piston rod through the intervention of a small subsidiary steam cylinder and piston which moves the slide valve, and is controlled, or timed, by a "Cataract." This controlling valve motion is connected to the main piston rod by a lever, or other means, in such a manner that whatever irregularity of motion exists in the engine is communicated to the valve motion, which, being set to run at a certain speed by the "Cataract," is unable either to go faster or slower. Therefore if the engine increases its speed it carries the valve motion with it, but in a contrary direction, and thus cuts off its own steam. Should the engine however run slower than the speed for which the "Cataract" is set, the subsidiary piston will open the main steam port through the motion it communicates to the main slide valve, and so admit more steam. Thus the speed of the engine is regulated to that of the "Cataract," which may be set to control the engine for fast speed or slow speed as required.

2. STEAM PUMP. Horizontal Direct-acting Steam Engine and Pump for Pumping and Draining purposes, or for feeding steam boilers with water. Cope and Maxwell's Patent.

Lent by Messrs. Hayward, Tyler, and Co., 84, Whitecross Street, E.C. 1874.

Note.—This direct-acting steam pump, designed by Cope and Maxwell, and introduced into England by Hayward Tyler, and Co., 1870–71, is known by the name of the "Universal" steam pump. It is essentially direct-acting. The piston itself performs the function of slide and exhaust valves to the engine, and will start at once to work. The engine and pump will act when submerged under water even ; and the

valves of the pump being exceedingly large and free, the pump is suitable for raising thick as well as thin liquids.

The steam cylinder of the engine is five inches in diameter. The stroke seven inches. The pump plunger is three inches in diameter. The pump will raise some 2,000 gallons of water per hour, forcing it 120 feet vertically.

3. SELF-ACTING STEAM RAM PUMP. The PULSOMETER. Hall's patent, U.S.A.

Lent by the Pulsometer Engineering Co., 61 and 62, Queen Victoria Street, E.C. 1876.

Note.—Self-acting steam pump, a novel application of the general principle involved in Savery's engine, A.D. 1702. The result is produced by the pressure of the steam from the boiler upon the surface of the water in each chamber of the pump alternately, without the intervention of any steam piston or plunger, and the water is lifted into the chambers by a vacuum produced without injection or surface condensation. The action of the steam ball, which governs the pulsations, is purely automatic, and the moving parts, including four valves, are only five in number.

4. WORKING MODEL of the "JET PUMP"; for draining purposes. Professor J. Thompson, Inventor. Edinburgh.

Lent 1876.

Note.—This pump, intended for raising water for drainage purposes from one level to another, works on the system of the syphon; and will act with a very small and even intermittent supply of water.

5. High-speed DONKEY PUMP, with slide valve; for feeding Steam Boilers with water, or pumping.

Lent by Messrs. J. Bourne and Co., 66, Mark Lane, E.C.

Note.—This donkey-engine and pump is exceedingly small and portable. The whole is contained on a bed-plate 2 feet 10 inches long by 10 inches broad. The diameter of the steam cylinder is 2½ inches, the stroke 4½ inches. Fly-wheel 10½ inches diameter. The pump valves are on the slide valve principle, and together with the steam slide valves of the engine are driven by one rod only, actuated by a very short throw crank on fly-wheel shaft working in a link. The great speed at which both engine and pump runs, accounts for the power and amount of work obtained from Mr. Bourne's high-speed system.

6. WORKING MODEL. The CHESTER PUMP. Improved pumping engine for forcing water applicable to mines, collieries, waterworks, &c.

Lent by Mr. H. E. Taylor, Engineer, 15, Newgate Street, and Sandycroft Foundry, Chester. 1878.

Note.—The driving engines have a pair of inclined cylinders supported by the engine framing externally. They are connected directly to a first motion wheel or pinion of 27 teeth which gears into the toothed wheel of 86 teeth, actuating the pumps. The engine, double cylinder, is simple in design; all its parts are easily accessible, and are designed for considerable wear and tear and rough work. The pumps are horizontal, single acting, with solid rams or plungers.

7. WORKING MODEL, of an HYDRAULIC PUMPING ENGINE. Designed by T. S. Truss 1875-6, Messrs. Chipperfield and Co., Machinists, 18, Kirby Street, Hatton Garden, E.C.

Lent 1876.

Note.—This pumping engine was proposed by Mr. Truss with a view of obtaining continuous motion from a single source of energy. The same water was to be used over and over again to drive the prime mover, a 3-cylinder Brotherhood hydraulic engine when once started. The 24 ram pumps driven by it through a revolving cam wheel set up on a vertical shaft and moving horizontally, keep up the water pressure required to drive the engine.

8. RECIPROCATING PUMP. Hand pump, working size, fitted with suction and delivery hose. An American pump, (Californian). Hansbrow's Patent, U.S.A.

Lent by Mr. Bennet Woodcroft, F.R.S. 1878.

9. ORIGINAL FAN or WHEEL; for an Appold Centrifugal Pump. Erected in 1852 to drain Whittlesea Mere.

Presented by Messrs Eastons and Anderson, Engineers, Whitehall Place, S.W. 1877.

Note.—Mr. John George Appold, born 1800, died 1865, noted for hydraulic and draining machinery, as also for many other mechanical inventions. The centrifugal pump, for which this old fan or wheel was an original design by Mr. Appold, was made by Messrs Eastons and Amos, Engineers, Southwark, and erected by them under Mr. Appold's direction at Whittlesea Mere 1852. The fan wheel exhibited has a cast-iron boss or centre, with rims and parabolic buckets of copper. It is 4 feet 6 inches in diameter out to out, and 1 foot 4 inches extreme width. Its weight is 8 cwt. 1 qr. 9 lbs. The fan has been constantly at work from 1852 to 1877, when it was found necessary to erect larger fans and pumping machinery to keep down the water on the Mere, the area of which is 6,600 acres.

10. DRAWING. Coloured Working Drawing on a scale of ¼ inch to 1 foot. The Original Appold Centrifugal Pump Station at Whittlesea Mere 1852.

Presented by Messrs Eastons and Anderson, Engineers, 3, Whitehall Place, S.W. 1877.

Note.—This drawing, framed and glazed, represents the original design for the pumping station erected in 1852 at Whittlesea Mere for the Appold centrifugal pump by Messrs. Eastons and Amos, Engineers. It shows a vertical through sectional elevation of the intake and of the output of the pump. A plan of same, and of the engine and boiler, coal store, and other details of the station. Mr. William Wells was the engineer of the drainage scheme and works for the drainage of Whittlesea Mere, the pumping is still carried on, but with larger pumps, on the Appold centrifugal system, and with more powerful engines and boilers to drive them, 1877.

11. MODEL (to scale) of a CENTRIFUGAL PUMP.

Lent by Messrs. Lawrence and Porter, Engineers, 36, Parliament Street, S.W. 1876.

Note.—This pump has been patented by Messrs. Lawrence and Porter. The chief feature of the patent is the arrangement of making one side of the casing removable. The advantages of this system are as follows: By taking off the moveable side the disc or "fan" can readily be examined or removed in a few minutes, without in any way disturbing or interfering with the suction or delivery pipes.

12. PUMPING ENGINE. Model in Wood. H. Davey's Patent Steam Compound Differential PUMPING ENGINE, with Double-plunger Pumps.

Lent by Messrs. Hathorn, Davey, and Co., Sun Foundry, Leeds. 1879.

Note.—The steam pumping engines represented by the model are essentially horizontal direct-acting steam pumping engines, and are now constructed by Messrs. Hathorn, Davey, and Co., of very considerable power and size. The model is constructed on a scale of . It was exhibited in 1878 at the Paris Universal Exhibition.

13. WORKING MODEL. Hydraulic PUMPING ENGINE. H. Davey, Inventor. For pumping water by means of an engine driven by water pressure.

Lent by Messrs. Hathorn, Davey, and Co., Sun Foundry, Leeds. 1879.

Note.—This pumping engine is driven by hydraulic or water-pressure power, and is a horizontal direct-acting engine and powerful pump. The model is a working model, constructed on a scale of . It was exhibited at the Paris Universal Exhibition of 1878.

14. SHIP'S PUMP. Full size illustration of Stone and Co.'s Patent Piston and Plunger Standard PUMP for ships' use.

Lent by Messrs. J. Stone and Co., Brass, Copper, and Iron Works, Deptford, S.E. 1879.

Note.—This powerful pump for hand use is now largely employed in the Royal and merchant service. The pumps differ in construction from those in ordinary use aboard ship, having two buckets each single acting and two pistons each double acting attached to separate pump rods, and working independently. They supply and force a very considerably increased amount of water, and are therefore valuable as fire-pumps, water-supply and bilge pumps, and for general service. There will be found a sectional drawing, with full description of the principles and construction of these pumps, which are said to be practically unchokeable, and in any case, from their arrangement, any mishap can be readily seen to. In the collection of ship models there is also a case containing specimens of ship's scuttles made by Messrs. Stone for all classes of ships of the Royal Navy and of commerce.

15. WORKING MODEL. Horizontal High Pressure COMPOUND ENGINE driving a pair of CENTRIFUGAL PUMPS. Scale of model ⅛th.

Lent by Messrs. J. and H. Gwynne, Engineers, Hammersmith Iron Works, Hammersmith. 1879.

Note.—The model represents one of a set of pumping engines erected by exhibitors at Codigoro near Ferrara, North Italy. The engine drives a pair of Gwynne's Centrifugal Pumps 54 inches in diameter. The pumping engines are capable of raising 2,000 tons of water per minute 10 to 12 feet high.

The model was made by Mr. A. J. Rixom, one of Messrs. Gwynne's pupils, 1874–5.

16. MODEL, in brass. Simmons' Patent ROTARY PUMP. J. Simmons, C.E., inventor.

Lent by Messrs. Whitley Partners, Railway Works, Leeds. 1879.

17. PHOTOGRAPH of Pearn's Patent Double-action Ram Force and Lift PUMP, with one Ram attached to a Direct-acting Inverted Cylinder Steam Engine.

Presented by Messrs. F. Pearn and Co., Engineers, Hulme Hall Road, Hulme, Manchester. 1874.

18. PHOTOGRAPH of a 3-Cylinder Steam Engine, attached to a 3-Cylinder PUMP.—P. Brotherhood's Patent System, 1874.

Presented by Messrs. Brotherhood and Hardingham, Engineers, Compton Street, E.C. 1875.

19. A WOODEN PUMP, from Japan. Presented by Mr. H. H. Howell, 55, Mark Lane, E.C. 1861.

Note.—These pumps were used by the Japanese as fire-engines. They are simply squirts made out of one piece of soft wood, bored through its centre, in which works a common rag plunger on the end of a stick. There is a moveable spout or nozzle attached to it by a curious iron clip. The whole is strengthened by thin copper bands fastened with copper nails.

CHINESE CHAIN PUMPS, working models of, &c. See Part II., pages 156, 165.

NOTE ON PUMPS.

The pump, perhaps one of the most useful of inventions, may be considered under two classes.

The common or lift pump universally employed to draw water from wells sunk in the earth; and the force pump, used not only to draw water from any given source, but also at the same time to raise or force it upwards to any height which may be required, in order that the water thus elevated should again fall by gravity and supply the necessities of cities and dwellings.

The common lift pump as well as the force pump are usually worked by hand-power, but both of them when constructed of very large size are driven by steam-power for innumerable purposes.

Pumps are said to have been invented with other hydraulic machines by Ctesibius of Alexandria about 224 B.C. The invention of pumps has also been ascribed to Danaus at Lindus about 1485 B.C. Pumps were in general use in England in 1425 A.D. In front of the Old Royal Exchange in the city of London there stood an old pump bearing an inscription to the effect, that the well underneath was sunk in 1282 A.D.

The air pump was invented in 1654 by Otto Guericke, German Philosopher 1602–1686, and improved upon, 1657, by Robert Boyle, 1627–1691.

FIRE-ENGINES.

20. SYRINGE OR SQUIRT. Old English. About 1750–1770. Used by Firemen for extinguishing fires in the City of London.

Presented by the Vestry and Parish of Saint Dionis. Backchurch, Fenchurch Street, E.C. 1877.

Note.—This old English Fire Squirt made of cast brass is 2 feet 3 inches long, and $2\frac{1}{2}$ inches in the bore of the barrel, and has a nozzle for the water jet. It is fitted with two handles probably for holding and directing it while in use, as well as for slinging it to the backs of the fireman for transport. Leather buckets were at this time also carried for supplying the squirts with water. In the Parish Church of Saint Dionis Backchurch, now pulled

down, three of these old fire squirts were, until lately, preserved.

21. MODEL. A MANUAL FIRE-ENGINE; used by the Metropolitan Fire Brigade. 1868.

Lent by Mr. B. Woodcroft, F.R.S. 1877.

22. COMPLETE WORKING MODEL. The most Improved Form of London Brigade MANUAL FIRE-ENGINE. 1868-9.

Messrs. Shand, Mason, and Co., Engineers, Upper Ground Street, Blackfriars, London.

Lent 1877.

Note.—The model represents the most modern form of a fire-engine to be worked by manual power, and is similar to those used daily by the London Fire Brigade Service.

NOTE ON MANUAL FIRE-ENGINES.

The earliest manual fire-engine constructed in England appears to have been made by Richard Newsham, pearl-button maker, of London, who was granted a patent for his fire-engine in 1721–1725. These engines had two pumps and an air vessel combined together, so as to ensure a continuous and uniform discharge of water with considerable force. The invention of Newsham is still the leading feature in all fire-engines, whether driven by manual or steam power. In 1876, at the Scientific Apparatus Exhibition, a Newsham fire-engine was exhibited. It is mounted on four wooden wheels, 1 foot 7 inches in diameter. The body forms the reservoir for water to supply the pumps which drive the water into the air vessel and out of which the water is forced by the pressure of the compressed air within it, into the discharging hose or pipe. The pumps are worked by long levers of wood for hand-power, and by treadles for foot-power. The brass ejection pipe of the engine is 1¾ inches in diameter, and it is screw-tapped in the usual manner to receive the hose pipe and nozzle.

STEAM FIRE-ENGINES.

23. COMPLETE WORKING ENGINE. The most Improved Form of London Brigade STEAM FIRE-ENGINE. 1878.

Note.—A steam fire-engine built for the Metropolitan Fire Brigade 1876–8, and stationed at the chief fire stations. It has a vertical single inverted cylinder steam-engine, driving a bucket and plunger pump. The boilers of the engines are usually constructed on the "Field" system as respects

the tubes; they are made of steel plates; work at a very high-pressure; and possess great rapidity in generating steam.

NOTE ON STEAM FIRE-ENGINES.

Fire-engines worked by steam power were introduced into England by Mr. John Braithwaite in 1829, and followed up in 1830 by an engine of six horse-power which worked successfully for five hours at a fire in London. In 1862 steam fire engines were permanently established in Great Britain.

The London Metropolitan Fire Brigade now possesses (1879) 36 steam fire-engines on its establishment, besides some five or six very powerful steam-power floating engines on the river, which are essentially steamboats and fire-engines combined. They are propelled by paddle-wheels or screws, and attain a high rate of speed.

WATER WHEELS.—TURBINES.

28. WORKING MODEL of an Overshot WATER WHEEL, showing the driving gear to the mill, and sluice. Also the necessary brickwork and setting.

J. Schroeder, Darmstadt. 1867.

Note.—This model represents an Iron Drum Wheel, with parabolic buckets or floats.

29. WORKING MODEL of an Undershot WATER WHEEL, showing the sluice, and elevation of the brickwork for the water way and setting of the wheel.

J. Schroeder, Darmstadt. 1867.

Note.—This model represents an arm or spoke "breast" wheel, having wooden floats or buckets.

These Models of Water Wheels are made by the pupils of Mr. J. Schroeder's Engineering School, Darmstadt.

Transferred from the Educational Collection 1867.

30. MODELS, in Wood, of WATER WHEELS of various Forms and Descriptions. French. Messrs. Hachette and Co., Paris and London.

See page 156.

Note.—These five models represent overshot and undershot water wheels, breast and scoop wheels. They are made in France and imported for educational purposes into England by Messrs. Hachette and Co., King William Street, Strand.

WATER POWER ENGINES.

32. MODEL. Brotherhood's Patent Three-cylinder HYDRAULIC ENGINE. Arranged for turning a capstan. The

water pressure being supplied to the engine by a Brotherhood's patent three-cylinder pump.

Lent by the Hydraulic Engineering Company, Limited, Chester. 1876.

Note—This model of an hydraulic or water pressure engine, arranged to drive a capstan for hauling purposes, was made by R. Chipperfield, Model Maker, 18, Kirby Street, Hatton Garden, E.C.

Hydraulic Presses.

Note.—Joseph Bramah, C.E., was the inventor of the hydraulic press which bears his name. He was born in 1749 and died in 1814. Originally a French engineer of repute, Bramah settled in England and invented many other ingenious contrivances, amongst them the celebrated Bramah lock, constructed principally for the security of important documents, money, &c., in fire-proof safes; for the use of bankers, merchants, and householders. The Hydraulic Press was invented in 1795.

34. Working Model. Watson's Patent Hydraulic Press.

Lent by Messrs. Fawcett, Preston, and Co., Engineers, Liverpool. 1879.

Note.—The principal object achieved in this press is the means afforded, it is said, for charging one portion with raw cotton for pressing without stopping the work in progress in the other portion of the press.

35. Hydraulic Lifting Jack. Ten-ton Jack.

Lent by Messrs. Tangye, Brothers, and Holman, 35, Queen Victoria Street, E.C. 1879.

Note.—These handy little jacks constructed and working on the principles involved in Bramah's hydraulic press, 1795, are made in all sizes from three tons upwards.

36. Screw Lifting and Traversing Jack; on a bed-plate and framing of steel. Twelve-ton Traversing Bottle Screw Jack.

Lent by Messrs. Tangye, Brothers, and Holman, 35, Queen Victoria Street, E.C. 1879.

Note.—Lifting jacks working with a screw for raising and lowering heavy weights, as well as traversing either way at will, were the original invention of George England, 1839. At the present time lifting and traversing screw jacks are of universal application for engineering purposes.

37. Water Closet Arrangement. Jenning's Patent; for preventing waste of water and foul air passing into service or main pipes.

Lent by Mr. G. Jennings, Palace Road, Lambeth. 1879.

AIR ENGINES.—WINDMILLS.

39. MODEL in wood of the FAN OF A SMOKE JACK. Made by Joseph Bramah in illustration of his proposal to apply the same form of vane for driving windmills. About 1800.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—This form of employing multiple sails or vanes for windmills is now very often applied to windmills employed in pumping or sawing, and for windmills driving pumps for the drainage or irrigation of land. These pumping and wood-sawing mills driven by the wind are in great use on the Continent, more particularly in Holland.

40. SECTIONAL Working MODEL in Wood of a WINDPOWER CORNMILL.—Showing the Sails, Driving gear, one pair of Stones, Flour Dressing machine, and Hoist. The mill is a post mill, and represents a French windmill. Messrs. Hachette and Co., Paris and London.

BLOWING MACHINES.

42. Sectional MODEL. Baker's Patent Pressure BLOWING MACHINE for smelting and other furnaces.

Lent by the Savile Street Foundry Company, Savile Street East, Sheffield. 1879.

Note.—Baker's Patent Blowing Machine was brought out in England a few years ago. It is capable of maintaining a pressure blast and will also serve for pumping purposes.

43. WORKING MODEL of Root's Patent PRESSURE BLOWER.

Messrs. Thwaites and Carbutt, Vulcan Iron Works, Bradford.

Purchased 1876.

Note.—This working model of Root's patent blowing machine for furnaces has attached to it a mercurial gauge and scale, showing the constant pressure of the blast supplied by the blower.

44. PHOTOGRAPH.—Root's Patent BLOWING MACHINE, attached to a Direct-acting Steam Engine.

Presented by Messrs. Thwaites and Carbutt, Vulcan Iron Works, Bradford. 1873.

45. PHOTOGRAPH of Root's Patent BLOWING MACHINE, for blowing the Furnaces of Iron and Metal Works, Smitheries, &c. Attached to a Vertical Steam Engine for driving same.

Presented by Messrs. Thwaites and Carbutt, Vulcan Iron Works, Bradford. 1873.

Note.—Root's Blowing Machine is an American invention. It is used in all branches of iron and metal manufacture, and wherever an air supply is required.

46. BELLOWS.—Used by Chinese smiths for blowing their charcoal fires.—From Tien-tsin.

Presented by Capt. Laurence Archer. 1862.

Note.—These bellows are made simply of an air-tight wooden box, with a wooden plunger working in it. The chamber is fitted with a wooden clack valve for directing the current of air to the nozzle of the bellows; and the air valves are simply holes in the sides of the box closed by coarse paper.

NOTE ON BLOWING MACHINES.

Blowing machines seem to have been first erected in England by Smeaton at the Carron Iron Works, N.B., in 1760. A large blowing machine equal to supplying air to 40 smiths' forge fires was erected about this time at Woolwich Dockyard.

The hot-air blast used for blowing iron smelting furnaces was invented by Mr. James Neilson, of Glasgow, in 1828. Mr. Neilson died in 1865. By this invention of the hot-air blast, *i. e.*, blowing machines driven by powerful steam engines and forcing hot or highly heated air into the metal smelting furnaces, a most important improvement in the production of iron was achieved, and a great economy gained in the consumption of the fuel used for smelting purposes. The hot-air blast is now of universal adoption in all iron smelting works.

CLASS V.

Machinery used in Public Works.

PILE DRIVING MACHINES.

1. WORKING MODEL of a Steam PILE DRIVING ENGINE for Submarine Foundations, and other work. Sissons and White's patent.

Lent by Messrs. Sissons and White, Hull. 1869.

Note.—This model, on about ½ inch scale, is a complete working illustration of a Steam Pile-driver. The winch to raise the monkey by an endless chain is driven through frictional gearing by the engine, which represents a high-pressure inverted cylinder direct-acting engine, having slide valve, eccentric, fly wheel, and force pump for feeding the boiler with water. The boiler represents an upright tubular boiler for working at high pressure.

2. MODEL of Vauloue's PILE DRIVING MACHINE.

Made by Jas. Ferguson, Esq., F.R.S. (the astronomer).

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—Vauloue's engine was used for driving the piles of old Westminster Bridge in 1739 and following years.

CRANES AND HOISTS.

3. WORKING MODEL in brass, on about ¼ scale; Patent CRANE with SELF-ACTING BUCKET or GRAB. For discharging coal, sand, seed, shingle, and for dredging purposes.

Lent by Messrs. Priestman Brothers, Holderness Foundry, Hull, and 95, Gracechurch Street, E.C. 1878.

Note.—Messrs. Priestman Brothers have now several large cranes at work, which are provided with the self-acting bucket or grab illustrated by the model. The bucket loads itself, and discharges at the will of the operator of the crane. These cranes when required for rapid and frequent use are driven and manipulated by steam power.

4. MODEL of a TRAVELLING CRANE; constructed by Messrs. Nepveu and Co., Paris, in 1855; employed in erecting the machinery in motion at the Paris Universal Exhibition of that year.

Made by Messrs. Nepveu and Co., Engineers and Contractors. Paris, 1855.

Presented by the late Captain Francis Fowke, R.E. 1859.

5. WORKING MODEL of a MINER'S LADDER and Lift.
French Manufacture.
Messrs. Hachette and Co., Paris and London.
See page 155.

6. MODEL, illustrating a STEAM HOIST. Constructed by Messrs. Turner and Co., Engineers, East Street, E.C., for raising and lowering heavy mail bags and parcels to the several floors of the General Post Office.

Lent by H.M. Postmaster General. 1876.

Note.—This model is a working model, and illustrates clearly the method adopted in the Hoist for the up and down as well as traversing motion of the lifts.

7. WORKING MODEL, on a scale of about ½ inch to 1 foot. RAILWAY TRAVELLING CRANE, used for clearing away Break-downs.

Purchased. 1877.

Note.—This model representing a railway break-down crane, is mounted on a proper 4-wheeled truck, and is fitted with the usual appliances; levers, movable counterpoise weight, and radiating body and jib.

8. MODEL of part of the JETTY and of the old SHEARS for masting ships. Sheerness Dockyard.

1864.

Note.—This model is exhibited with the models of ships.

STONE BREAKING AND CRUSHING MACHINERY.

9. MODEL of a STONE BREAKING, Crushing, and Gold Amalgamating MACHINE.

Designed and lent by the Patentee and Maker, Mr. G. H. Goodman, 53, Penrose Street, Newington. 1872.

10. MODEL of a MACHINE to be driven by Steam Power for Cutting and Sizing Roofing Slates.

Lent by Mr. J. W. Greaves, Slate Merchant, Port Madoc. 1862.

10*a*. MODEL in Wood. "Gimson" Patent Duplex STONE BREAKER. Machine for producing road pitchings, and crushing ores and minerals.

Lent by Messrs. L. Swift and Co., 11, Laurence Pountney Lane, E.C. 1879.

Note.—Stone breaking machines are now thoroughly well established in England. Originally brought out in America some 10 years ago, the names of Blake, Marsden, Hall, and other improvers and makers of this class of machinery

are well known, and the variations in details and principles of their action and construction well understood and easily obtained from popular sources of information. These machines are often employed for breaking stone for road making on the system of Mr. John MacAdam, brought out by him in Ayrshire in 1819, and known by the name of Macadamized Roads.

ROAD ROLLERS.

Note.—Steam Road Rollers were originally the design of an Englishman, but they were first adopted for public service by the City of Paris in 1865. In 1867 they were first used in London.

COAL SHIPPING MACHINERY.

11. WORKING MODEL of a plan for TIPPING AND SCREENING COALS into Railway Waggons at one operation.

Designed and lent by Mr. James Rigg, C.E., George Street, Chester. 1870.

12. WORKING MODEL of a plan for TIPPING COALS from Railway Waggons, into Ships and Colliers.

Designed and lent by Mr. James Rigg, C.E., George Street, Chester. 1870.

13. MODEL of SPOUT, used in the Sunderland Docks for loading vessels with coals.

Lent by the River Wear Commissioners, Sunderland. 1876.

14. MODEL of LOADING DROPS, used in Sunderland Docks for lowering or dropping coal trucks from a high to a low level.

Lent by the River Wear Commissioners, Sunderland. 1876.

14*a*. WORKING MODEL. Patent apparatus for saving the Breakage of COAL when loading from colliery screens into coal wagons.

Lent by Messrs. A. M. Potter and T. C. Hair, Shire Moor Colliery, Earsdon, Northumberland. 1879.

Note.—"Round" coal being of greater value than "small," the apparatus represented by the model has been devised by Messrs. Potter and Hair with a view of producing as much "round" coal as possible whilst loading into wagons from the pit tubs or corves and screening. This object is attained at the Shire Moor Colliery by means of the apparatus illustrated, which consists in the application of a tray in front of the screen controlled by balance weights and chains. When the weight of the screened coal on the tray becomes heavier than the balance weights, they are disengaged, and

the tray descends into the coal truck or wagon. When reaching its proper depth the chain at the back of the tray is checked, which cants it up and causes all the coal to slide off the tray without any fall into the wagon. The tray being now empty, the balance weights bring it back to its original place and keep it there. The whole machine is thus self-acting, but the screeners have to regulate the descent of the tray from time to time to suit the filling of the wagon.

Diving Apparatus.

15. Sectional Model of a Diving Bell for sub-marine explorations. The Model illustrates an arrangement by Dr. John Taylor, for supplying air to the bell in an upward jet near the mouth; so that in case of the bursting of the air hose, or the failure of the stop-valve (usually placed on the top of the bell) the water would only rise to the level of the air-pipe nozzle.

Presented by the late Dr. John Taylor, M.D., Professor of Natural Philosophy, in the Andersonian University, Glasgow. 1874.

Note.—A Diving Bell is first mentioned by Aristotle, the Greek Philosopher 384–322 B.C., about 325 B.C. Used in Europe A.D. 1509. The first use made of the diving bell in Britain appears to have been in 1662, in searching for wrecks of part of the Spanish Armada off the coast of Mull. Halley, in 1721, greatly improved the diving-bell. Smeaton employed it in his improvement works at Ramsgate Harbour 1779–1788. A diving machine containing reservoirs of compressed air and capable of sustaining two persons under water for 50 hours, the invention of Toselli, a Venetian, was used with success in the Bay of Naples 1871.

16. First Helmet made for Diving Purposes, in 1829.

Lent by Messrs. Siebe and Gorman, Denmark Street, Soho. 1876.

17. Patent Helmet for Diving, fitted with segmental neck ring and safety locking arrangement, inflating valve for bringing diver to the surface. Fitted with speaking apparatus to enable the diver to communicate with his attendant. Used on board H.M. Ships of the Royal Navy.

Lent by Messrs. Siebe and Gorman, Denmark Street, Soho. 1876.

Note.—The diving dress used by divers for submarine explorations was first made by Mr. Siebe in 1836. It was used at Portsmouth in 1838 by the late Sir Charles W. Pasley, Royal Engineers, in his recovery of the "Royal George" ship of war, sunk in the Harbour 1782.

WATER SUPPLY APPARATUS.

18. Full size Norton's Patent TUBE WELL. For sinking wells by means of wrought-iron pipes or tubes driven into the ground by a small monkey driver working round the tube and striking on a clamp grasping the tube firmly.

Lent by Messrs. Le Grand and Sutcliffe, Artesian Well Engineers, 100, Bunhill Row, E.C. 1879.

Note.—These tube wells are of American origin. Some ten years since they were introduced into England. Mr. J. L. Norton worked out the design into practical utility. These tube wells and the apparatus for sinking or driving them need no detailed description. They were employed in the expedition to Abyssinia in 1868, and have since formed part of the equipment of the Royal Engineer trains for army service wherever the question of water supply is a grave consideration.

A tube well of $1\frac{1}{4}$ inches diameter has furnished a supply of water equal to 500 to 600 gallons per hour. The tubes can be driven with care to a depth of some 150 to 300 feet, but they are generally successful in giving a supply of water at a less depth. Messrs. Le Grand and Sutcliffe have modified the original method of driving these tube wells, by striking the leading tube head itself with a monkey or heavy striker working inside the tubes instead of outside. This method applies only to tubes of an internal diameter sufficient to allow an effective striker to work. The tubes, if required, can be withdrawn, after sinking to a moderate depth, and so long as they are straight can be used several times over.

18*a*. TUBE WELLS. Working model illustrating Legrand and Sutcliffe's DRIVING APPARATUS for sinking the leading tubes of Norton's Patent Tube Wells.

Lent by Messrs. Legrand and Sutcliffe, Artesian Well Engineers, 100, Bunhill Row, E.C. 1879.

Note.—This model represents an improved method devised by Messrs. Legrand and Sutcliffe for driving the leading tubes of the Patent Tube Wells.

19. Kennedy's Patent WATER METERS. Two working meters, full size.

Kennedy's Patent Water Meter Company, Limited, Kilmarnock, N.B.

Lent 1878.

Note.—The meter having a glass cylinder, is applicable to measuring a supply of water through a $\frac{5}{8}$-inch pipe. The cylinder is of glass, simply to show the action of the water upon the meter when at work. The other meter represents a

complete working instrument for a service through $\frac{1}{2}$-inch pipe.

20. WATER METER. Siemens and Adamson's Patent Water Meter for half-inch service; in section, showing interior construction and arrangement.

The meter will measure 500 gallons of water per hour.

Lent by Messrs. Guest and Chrimes, Makers, Rotherham. 1862.

21. SECTION of a HALF-INCH BIB COCK, for High-pressure water service, with double-action loose valve.

These bib cocks can be repaired without turning off the water.

Lent by Messrs. Guest and Chrimes, Makers, Rotherham. 1862.

22. SECTION of a HALF-INCH BIB-COCK, for High-pressure water service, with union joint on nose.

Lent by Messrs. Guest and Chrimes, Makers, Rotherham. 1862.

23. HALF-INCH MEASURING DRUM; Siemens and Adamson's Patent for High-pressure Water Meter. Will measure 500 gallons of water per hour.

Lent by Messrs. Guest and Chrimes, Rotherham. 1862.

24. ONE-AND-A-HALF-INCH MEASURING DRUM, for Siemens and Adamson's Patent High-pressure Water Meter. Will measure 5,000 gallons per hour.

Lent by Messrs. Guest and Chrimes, Rotherham. 1862.

25. BRASS BIB-COCKS, STOP-COCKS, and ordinary COCKS. For use in breweries, distilleries, refineries, &c.

Messrs. Guest and Chrimes, Manufacturers, Rotherham, and 83, Southwark Street, S.E.

Presented. 1862.

Note.—This series of Brass Cocks for Water Service, comprises the following:—

a. Brass cocks:—

12 in. long, 2 in. diam.; 9 in. long, $1\frac{1}{2}$ in. diam.; 8 in. long $1\frac{1}{4}$ in. diam.; $6\frac{1}{2}$ in. long, 1 in. diam.; $5\frac{1}{2}$ in. long, $\frac{3}{4}$ in. diam. 5 in. long, $\frac{5}{8}$ in. diam.; $4\frac{1}{2}$ in. long, $\frac{1}{2}$ in. diam.; 4 in. long, $\frac{3}{8}$ in. diam.

b. Stop-cocks:—

12 in. long, 2 in. diam.; 8 in. long, $1\frac{1}{2}$ in. diam.; 8 in. long; $1\frac{1}{4}$ in. diam.; 6 in. long, 1 in. diam.; $5\frac{1}{2}$ in. long, $\frac{3}{4}$ in. diam. 5 in. long, $\frac{5}{8}$ in. diam.; $4\frac{1}{2}$ in. long, $\frac{1}{2}$ in. diam.; $4\frac{1}{2}$ in. long $\frac{3}{8}$ in. diam.

c. Bib-cocks :—

$9\frac{1}{2}$ in. long, $1\frac{1}{2}$ in. diam.; $7\frac{1}{4}$ in. long, $1\frac{1}{4}$ in. diam.; $6\frac{1}{2}$ in. long, 1 in. diam.; $5\frac{1}{2}$ in. long, $\frac{3}{4}$ in. diam.; 5 in. long, $\frac{5}{8}$ in. diam.; $4\frac{1}{2}$ in. long, $\frac{1}{2}$ in. diam.; 4 in. long, $\frac{3}{8}$ in. diam.

d. Bib-cocks, with Ball and Lever :—

6 in. long, 1 in. diam.; lever, 20 in. long, ball, 6 in. diam.; 4 in. long, $\frac{3}{8}$ in. diam.; lever, 15 in. long, ball, 4 in. diam.

e. Taps, with Ball and Lever :—

4 in. long, 1 in. diam.; lever, $22\frac{1}{2}$ in. long, ball, 6 in. diam.; 3 in. long, $\frac{3}{8}$ in. diam.; lever, 15 in. long, ball, 4 in. diam.; 4 in. long, 1 in. diam.; lever, 15 in. long, ball, 6 in. diam.; 2 in. long, $\frac{1}{2}$ in. diam.; lever, 15 in. long, ball, 4 in. diam.

Presented by Messrs. Guest and Chrimes. 1862.

26. TWO-INCH STREET WATER HYDRANT, in brass, complete; attached to water service main.

Lent by Mr. George Jennings, Palace Road, Lambeth. 1874.

27. BRASS BIB-COCKS and VALVES, for Hot and Cold Water Service.

Six brass Bib-Cocks for Hot and Cold Water Service.
One $1\frac{1}{4}$-inch brass Steam Cock for Hot Water Service.
One 1-inch brass Steam Cock for Hot Water Service.

Lent by Mr. George Jennings, Palace Road, Lambeth. 1874.

28. SPECIMENS. Three Patent WELDED Wrought-iron TUBES or PIPES, coated with Professor Barff's solution for the prevention of rust.

Lent by Mr. John Spencer, C.E., 97, Cannon Street, E.C. 1879.

Note.—These pipes, coated inside and out under the process of Professor Barff, for the prevention of rust and corrosion, have been buried underground for several months, and do not exhibit any signs of deterioration.

29. WATER GOVERNOR. Water Governor for controlling the flow of water through main pipes. Foulis' Patent.

Lent by Mr. W. Foulis, 42, Virginia Street, Glasgow. 1879.

Note.—Foulis' Patent Water Governor is applied for controlling the pressure and flow of water in the large mains and supply pipes used for water supply to cities and towns. A coloured diagram is exhibited, showing the principle of action and interior of this water governor. Messrs. Alley and Maclemene, Virginia Street, Glasgow, are the makers and agents.

Gas Supply Apparatus.

Note on Gas Supply Apparatus.

Gas, in chemistry, is accounted as a permanently elastic aeriform fluid, such as the now well-known gases hydrogen, oxygen, nitrogen, chlorine, and others.

Michael Faraday, the most renowned English physicist of modern time, born at Newington, Surrey, 1791, died 1867, determined and formulated the properties of a gas in 1823. He was apprenticed in 1804 to the book-binding trade. In 1813 Faraday was appointed, owing to his chemical knowledge, assistant to Sir Humphrey Davy in the Royal Institution. In 1820 Faraday reported his discovery of chloride of carbon. His researches and lectures upon chemical and electrical discoveries are of universal reputation.

Coal gas. The inflammable aeriform fluid, known as carburetted hydrogen, evolved by the combustion of coal, was described by Rev. Dr. Clayton in 1793. Coal seems, with historical truth, to have been known to and used by the ancient Britons. The Romans, however, do not appear to have known of the existence of coal in Britain. Henry III. is said to have first granted a license in 1234 to dig coal near Newcastle. Coal was traded with from Newcastle to London in the time of Richard II., 1381, and was generally used as fuel in London in 1400. In 1625 coal became permanently in common use in England. It was brought to Dublin in 1742 from Newry. Wood had hitherto chiefly served for fuel. The Coal Exchange was established in London in 1807, and the present Coal Exchange building in the City, erected by Mr. J. B. Bunning, was opened in October 1849.

Coal gas, as employed for illuminating purposes, was the invention of William Murdoch, born in Ayrshire in 1754. In 1777 Murdoch joined Boulton and Watt, the celebrated engineers of Soho Works, Birmingham, and afterwards went to Cornwall on business for them. It was at Redruth in 1792 that Murdoch first achieved an apparatus for making and distributing coal gas for illumination, and lit his house and works there with it. In 1798, having perfected his gas apparatus, he lit up the works of Messrs. Boulton and Watt at Birmingham, and in 1802 employed gas for the external illumination of the factory. William Murdoch died in 1839.

Gas, for illuminating purposes, has also been obtained from oil and resin by Taylor 1815, Laming and Evans 1850. Water gas, or gas obtained from water, was patented by Donovan, 1830; Lowe, 1832; Manby, 1839; White, 1847–49; and by others up to 1873. Photogenic gas was brought out by Mongruel in 1862.

In 1803 coal gas was first used in London to light the Lyceum Theatre, as an experiment, by Mr. Winsor. In

1804–5 Murdoch lit 1,000 burners nightly at the cotton mills of Messrs. Phillips and Lee, Manchester. Gas lighting for streets was first introduced into London at Golden Lane in 1807; Pall Mall, 1809; and generally in 1814–20. Dublin was lit with gas in 1818, and permanently in 1825. Paris was lighted by gas 1819, and Sydney (Australia) in 1841. Gas was first used to light railway trains in 1862 by Mr. Allen, Scottish Central Railway, and for lighthouse illumination gas was first employed in 1869 at the Howth Light, Dublin Bay.

Gas Meters. Gas meters, machines for the measurement of gas through water, were patented in 1815 by Samuel Clegg; in 1824 by Sir William Congreve, born 1772, died 1828, and celebrated for his military rockets; Nathan Defries 1838; and by other gas engineers. Dry gas meters were patented, it is said, by John Malam in 1820, and by Nathan Defries in 1844.

ELECTRIC LIGHT APPARATUS.

30. WILDE Electro-Magnetic INDUCTION MACHINE. For six lights.

Lent by the Electric Lighting Company, 43, Lothbury, E.C. 1879.

31. WILDE Electro-Magnetic INDUCTION MACHINE. Smaller size for four lights.

Lent by the Electric Lighting Company, 43, Lothbury, E.C. 1879.

32. STANDARD LAMP-POST and Lamp. For the Wilde Electric Light.

Lent by the Electric Lighting Company, 43, Lothbury, E.C. 1879.

Note.—For a description of the peculiarities of Mr. Wilde's arrangements in his electric generators and automatic action lamps for electric light, consult a work published by Ferguson on "electricity," or Paget Higgs on "the history of electric lighting."

33. DE MERITENS' Electro-Magnetic MACHINE. Baron Alexander De Meritens, Paris, 1877.

Lent per Mr. J. N. Shoolbred, 3, Westminster Chambers, S.W. 1879.

Note.—The De Meritens electro-magnetic machine or electric generator is purely a magnetic machine, employing powerful horse-shoe magnets for the generation of electricity.

34. TISLEY'S Dynamo-Magnetic MACHINE; with single wire armature.

Lent by Messrs. S. C. Tisley and Co., 172, Brompton Road, S.W. 1879.

35. GRAMME Dynamo-Electric MACHINE. Invented by M. Gramme, Paris, 1860–61.

Lent by the India-Rubber. and Telegraph Works Co., Silvertown, E., per Mr. J. N. Shoolbred. 1879.

Note.—For the difference of the principles involved in the electro-magnetic and dynamo-magnetic electric generators, &c., see a little work on electricity written by Ferguson, Ure's Arts and Manufactures, and Paget Higgs on the electric light.

36. PHOTOGRAPHS. Four in number, framed and glazed. Portable ELECTRIC Generator MACHINES and LIGHTS. Driven by steam power and mounted on carriages and wheels for transport by horses.

Lent by Messrs. Sautter, Lemonnier, and Co., Avenue de Suffren, Paris, per Mr. J. N. Shoolbred, 3, Westminster Chambers, S.W. 1879.

Note.—These portable electric machines and lights have been arranged by Messrs. Sautter, Lemonnier, and Co., for naval, military, and other purposes. The lights are enclosed in lamps fitted with powerful reflectors and lenses for projecting the light in any given direction. These lamps, or rather light reflecting and projecting apparatus, are technically known as Holophotes.

37. ELECTRIC LIGHT. Rapieff Lamp, burning four carbons at once, and arranged as a table lamp, with blue and white china body and opal globe.

Lent by the National Electric Light Company, per Mr. J. N. Schoolbred, C.E., 3, Westminster Chambers, S.W. 1879.

38. ELECTRIC LIGHT. Rapieff Experimental Lamp on wooden stand; burning three carbons and shaded by opal glass.

Lent by the National Electric Light Co., per Mr. J. N. Shoolbred, C.E., 3, Westminster Chambers, S.W. 1879.

39. ELECTRIC LIGHT. Rapieff Candle or Carbon Holder for Electric Light. Burning two pairs of small carbons.

Lent by the National Electric Light Co., per Mr. J.N. Shoolbred, C.E., 3, Westminster Chambers, S.W. 1879

40. ELECTRIC LIGHT. Rapieff Candle or Carbon Holder for Electric Light. Burning a pair of candles or carbons on the Jablochkoff system.

Lent by the National Electric Light Co., per Mr. J. N. Shoolbred, C.E., 3, Westminster Chambers, S.W. 1879.

41. ELECTRIC LIGHT. Rapieff Candle or Carbon Holder. Burning three carbons; two small carbons above, and one ¾-inch carbon underneath.

Lent by the National Electric Light Co., per Mr. J. N. Shoolbred, C.E., 3, Westminster Chambers, S.W. 1879.

42. CARBONS OR CANDLES. For Electric Light. A collection of Carbons or candles of English and Foreign manufacture, and of various sizes and descriptions.

Lent by Mr. J. N. Shoolbred, 3, Westminster Chambers, Victoria Street, S.W. 1879.

Note.—This collection of candles for electric lights illustrates the several varieties now in use for electric lighting. Candles or carbons will be found ranging from 1-inch diameter down to the thinnest size used, together with examples of the Jablochkoff, Siemens, and other carbons.

NOTE ON ELECTRIC LIGHTING.

It may not be out of place to record a few facts connected with the recent application of electricity to public illumination.

The electric property of amber, when rubbed, is said to have been known to Thales, the Greek philosopher, B.C. 600.

In 1600 A.D. Gilbert records that other bodies besides amber generate electricity when rubbed. Otto von Guericke, German philosopher, 1602–1686, constructed the first electric machine in 1647. Boyle published "Electrical Experiments" 1676, and, with Sir Isaac Newton, employed glass as a source of electricity 1675.

Sulzer, a German clergyman, 1720–1779, first noticed Galvanism in reporting the disagreeable sensation experienced by placing the tongue between two pieces of different metals, *e.g.* silver and lead. Madame Galvani, in 1789, observed the action of the muscles of a frog when brought into contact with two metals; and, on this discovery, Galvani, Italian physician and philosopher, 1737–1798, devised the galvanic battery in 1791. Magnetism, or the attractive power of the loadstone or natural magnet, is mentioned by Homer, Aristotle, and Pliny, and was also known to the

Arabians and Chinese. The Greeks are said to have obtained the loadstone from Magnesia, in Asia, B.C. 1000. Roger Bacon appears to have been acquainted with the property of the loadstone in pointing to the north, A.D. 1294. The mariners' compass is attributed to Flavio Gioia, a Neapolitan, 1310, but seems to have been known at an earlier time in Europe, to Norway 1266, and in France 1150. Artificial magnets were made in 1746 by Dr. Gowan Knight.

Lord Justice The Hon. Sir William Grove, F.R.S., LL.D., made the first great step towards the application of electricity to illumination by his invention, in 1839, of the Grove-Voltaic battery. Volta, the Italian physicist, discovered the development of electricity in metallic bodies 1775, and constructed the Voltaic-Pile 1793. In 1816 Volta published a volume of Researches in Electricity. He was born 1745, and died 1827. The name of Benjamin Franklin, the American philosopher and statesman, born 1706, died 1790, should also be here recorded as a worker and discoverer in electric science. In 1750 Franklin proved the identity of the electric spark with natural lightning by means of his famous experiment with a kite.

In 1877–78 the great thoroughfare in Paris, L'Avenue de l'Opera, was illuminated nightly for many months on the Jablochkoff system of electric light by the Société Générale d'Electricité. This system was introduced into London in 1878–79, and employed to light the Thames Victoria Embankment. At the present date the following are the principal systems carried out in England with success for the purpose of public lighting by electricity: Higgins' incandescent light, the electricity for which is produced by galvanic batteries; the Electric Lighting Company employing the system of Mr. Wilde, comprising automatic-action carbon holders and Wilde electro-magnetic induction machines; the Werdermann light system, H. F. Joel, C.E., engineer and manager; the British Electric Light Company also using automatic-action arrangements for holding the carbons, the electricity being derived from Gramme's quantity machines or other electric generators; the system of Messrs. Siemens Brothers, who are inventors of improved electric generator machines, as well as electric automatic lamps; the Société Générale d'Electricité working the Jablochkoff system of light both in Paris and London. It must be understood that the electric generator machines spoken of require to be driven by powerful steam or other engines at very high speed indeed, and with the utmost possible steadiness. These machines are now best known as magneto-electric and dynamo-electric machines. The former are represented by the Holmes magneto-electric and the Baron de Meritens' magneto-electric machines, the latter by the Gramme, Siemens, Schuckert, and other generators.

The number of inventors and of patents taken out by them for improvements in the working parts and arrangements of electric lamps and lights is very great, and beyond possibility of full mention. Some of the most recent inventions, however, are those of Messrs. Rapieff, Duboscq, Krupp, Serin, Edison, Brush, Wallace and Farmer, &c.

The earliest successful application of the electric light to public purposes was probably by Professor Holmes, who, in 1858, contrived the magneto-electric generator and electric lamp, which were employed, and the light shown in that year at the South Foreland lighthouses. In 1862 an improved apparatus and light by Professor Holmes was displayed at Dungeness. Monsieur Serin, of Paris, quickly followed Professor Holmes in the application of electricity to lighthouse illumination on the coast of France. Mr. H. Wilde's electric light apparatus was also successfully used in 1866 for lighting some of the northern British lighthouses.

CLASS VI.

Objects in Machinery used in the Arts and in Manufactures.

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1. Working AUTOTYPOGRAPHIC PRESS; for impressing drawings on metal plates by mechanical means, and afterwards printing them from the plates by the usual method employed for copper-plate printing.

Lent by the inventor, Mr. George Wallis. 1877.

Note.—With this press will be found a series of illustrations showing the various processes and stages of manipulation and proof engravings.

2. PRINTING MACHINERY. Portions of a Circular or Cylinder Printing Machine. Designed by the late Sir Rowland Hill, K.C.B., and patented in 1835.

Lent by Mr. Pearson Hill, Belsize Park. 1877.

Note.—The portions exhibited of this Rotatory Printing Machine, invented by Sir Rowland Hill, consist of two printing rollers or cylinders, and a portion of the type inking machinery. The object aimed at in this machine was chiefly the quick printing of newspapers on a continuous roll of paper, by means of moveable type or stereotype plates arranged in a curved form to suit the peripheries of the printing cylinders.

A perfect working machine was constructed and exhibited in London in 1835. In it one cylinder was covered with moveable type and the other with curved stereotype plates. The machine gave very excellent impressions with very great rapidity.

3. EXAMPLES of the ORIGINAL CURVED CASES and MOVEABLE TYPE set up in them, for printing newspaper columns. Invented by the late Sir Rowland Hill, K.C.B., in 1835, for his Rotatory Printing Machine.

Lent by Mr. Pearson Hill, Belsize Park. 1877.

Note.—With these examples of the curved type invented by Sir Rowland Hill for printing by rotatory cylinders, which are exhibited in a glass case, an explanatory diagram and letter-press will be found, which describes in full, the detail of setting up the moveable type in their cases and attaching them to the periphery of the printing rollers. There are also lent for exhibition by Mr. Pearson Hill nine original drawings of detail got out by Sir Rowland Hill in 1835 for securing

the patent right of his invention; "Printing by rotatory cylinders on a continuous roll of paper."

4. ORIGINAL ROLLER in METAL. One of the Rollers with gear wheel and axle fitted to it; used in Sir Rowland Hill's Rotatory Printing Machine, 1835.

Lent by Mr. Pearson Hill, Belsize Park. 1877.

Note.—This Old Roller shows the method devised by Sir Rowland Hill for fixing the curved printing type, and cases to its periphery, and at the same time affording means for their proper adjustment and removal as occasion required.

5. OLD WOODEN ROLLER. Fitted with axle and gear wheel; and used in Sir Rowland Hill's Original Printing Machine, 1835.

Lent by Mr. Pearson Hill, Belsize Park. 1877.

Note.—This Old Wooden Roller probably carried in Sir Rowland Hill's Rotatory Printing Machine, the stereotype metal plates employed by him for printing newspapers and other work requiring great rapidity of production.

6. A PORTION, Full size. The INKING ROLLERS and Apparatus devised by the late Sir Rowland Hill, K.C.B., 1835, for inking the curved types and stereotype plates of his Rotatory Printing Machine.

Lent by Mr. Pearson Hill, Belsize Park. 1877.

Note.—The modern inking apparatus used in steam printing machines are all more or less founded upon the principle of this invention of Sir Rowland Hill. It must be understood that the modern inking table for steam printing machines is very considerably larger, and has far more detail for producing perfect work than this original printing type inking apparatus.

7. PRINTING PRESSES. For small jobbing. Hand power Presses.

Messrs. C. G. Squintani and Co., Printing Material Dealers, 3, Ludgate Circus Buildings, E.C.

Lent 1879.

The three different sizes exhibited represent:

No. 1. The smallest size printing press on the lever principle.

No. 2. A press, on a larger scale, on the lever principle for small jobbing work.

No. 3. A printing press of large size for heavier work, driven by manual or foot power.

8. PRINTERS' STICK. An Old English Printers' Composing Stick.

Presented by Mr. C. Goulden, St. Peter's Street, Canterbury. 1878.

Note. — This old printers' composing stick is made of hard wood. It was found in an old printing office at Canterbury, and is said to be at least one hundred years old. Length, extreme, 7 inches, length of type nick, 5 inches. Extreme breadth of stick 1¾ inches, and of nick 1⅛ inches.

9. STAMPING TABLE, used by H.M. Post Office for the marking and stamping of letters.

Lent by H.M. Postmaster General. 1876.

Note.—This table for stamping letters has fixed to it a self-inking stamp on a radial arm, which ensures great rapidity of action in stamping letters. The stamp being once arranged for its work inks itself automatically.

NOTE ON PRINTING MACHINES.

The art of printing by Blocks appears to have been invented by the Chinese, A.D. 593; moveable type were made in the 10th century. The honour of first printing by type in Europe is given to the following cities, Mentz, Strasburg, Haarlem, Basle, Venice, Rome, Florence, and Augsburg; but to the three first named cities, most prominence is accorded for the invention and development of the Art of Printing.

In England, the first printing press set up was devised by William Caxton, a Mercer of London, and worked by him in Westminster Abbey in 1470. Printing presses were first used in Scotland in 1509. Newspapers were first printed in England in 1588. Printing type were first cast and made in England by Caslon in 1720. Stereotype printing was first practised in Edinburgh by Mr. Ged in 1730. Lithographic printing was introduced by Mr. H. Johnson and Mr. Walter, proprietor of the Times, in 1783. Machine printing was first suggested in England by Nicholson in 1790. Printing by machinery has become of universal adoption throughout the world, wherever great rapidity and vast quantity of production of printed matter are required. Printing by the Anostatic process, *i.e.*, the written or printed matter is transferred to zinc plates, and from them printed off in quantity, was introduced by Baldernus of Berlin, in 1841, and was developed in London in 1848. Type composing machines, or machines for setting up printing type by mechanical means instead of by manual labour, were first brought out by William Young in December 1842. A machine for composing or setting up type for printing, and for subsequently distributing it into individual letters, was exhibited in motion at the London International Exhibition of 1872.

Engraving Machines.

10. Machine for Engraving Duplicates of Medallions, Sculpture, &c.—J. Bates' Patent, 1823.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—The object of this machine is to copy or engrave on metal plates an exact representation of original medals, sculpture, and other works of art executed in relief.

There will be found exhibited with this engraving machine specimens of its work, in the form of medallions with low relief ornaments; and samples of printed work from plates engraved by the machine.

Letter Copying Presses.

11. Original Roller Press; for Copying Letters. Designed by James Watt, 1780.

Lent by Mr. B. Woodcroft, F.R.S. 1877.

Note.—This roller letter copying press was intended for copying the business correspondence of commercial men or any other calling requiring copies of voluminous correspondence to be quickly made. The screw press has however now superseded these roller presses.

12. Original Letter Copying Press. Designed by James Watt, and manufactured at his Soho Works, Birmingham.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—This letter copying press for private use is fitted to the front part of an old fashioned writing desk, in the well of which are contained the necessary oiled paper, damping and drying pads, copying paper, &c. At one side of the desk two brass rollers, one above the other, are firmly fitted. The top roller being driven by a moveable handle forces the papers to be copied between the rollers and out through the side of the desk. When the press is not required for use the desk serves for ordinary writing purposes, and the whole can be shut up and locked in the ordinary manner of old fashioned wooden writing desks.

Drying Machines, Centrifugal and other.

Note.—Models in this group are wanting at present. There is however a coloured drawing of a centrifugal drying machine of Belgian construction. See Class IX. No. 15, page 146. Monsieur Fouquemberg's Patent.

MACHINES FOR TESTING MATERIALS.

14. MACHINE for TESTING the Strength of CEMENTS. Designed by V. de Michele, C.E., 1873. Manufactured by the exhibitors, Messrs. Alexander Wilson and Co., Engineers, Wandsworth Road, S.

Lent 1876.

Note.—This machine is designed on the lever principle, the long arm of which carries a given weight raised by a worm and screw motion driven by hand, the short arm is attached to a gun-metal frame made in two halves and joined at top and bottom by adjustment screws. Into this frame the block of cement to be tested is placed. By means of the adjustment screws to the clips, the block of cement in the frame is made to bear the full strain or pull of the weight on the long end of the lever. There is an index and pointer attached to the machine which indicates in pounds the actual weight supported per square inch by the cement up to and at the moment of fracture.

15. PAPER TESTING MACHINE. Carrington's Patent; for testing the strength of paper. Used by Her Majesty's Stationery Office, the Bank of England, and paper manufacturers.

Lent by Mr. W. Carrington, 77, Cheapside, E.C. 1879.

Note.—The working principle of this paper testing machine is similar to that employed in the Michele machine for testing the strengths of cements. *See* No. 14.

16. BONE CRUSHING MACHINE. Working size, for Hand-power. An early machine for crushing bones; made by Crook, Carnaby Street, E.C.

Lent by Mr. Bennet Woodcroft, F.R.S. 1878.

17. WORKING MACHINE. A PAPIN DIGESTER. Used for softening bones and many other substances, for manufacturing purposes.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

Note.—Denis Papin, the inventor of this machine, was born at Blois, in France, 1647. In 1680 he became a fellow of the Royal Society of England. He made many experiments to improve the steam-engine, and devised "The new Digester" or engine for softening bones in 1681; which machines are known as Papin Digesters to the present day. They consist essentially of a steam boiler capable of bearing an exceedingly high steam pressure, within which the substances are "digested." Papin died in 1714.

Mining Machinery.

18. Working Model, in Metal, of Patent Drum Dresser—For ores and minerals.

Lent by Mr. H. E. Taylor, Engineer, 15, Newgate Street, and Sandycroft Foundry, Chester. 1878.

Note.—The model represents a machine to be driven by horse, water, or steam power used by miners for dressing minerals, ores, and divers materials requiring sorting and dressing.

Three conical cylinders fixed to and revolving with a horizontal axle receive the material at one end, and by the continual revolution of these cylinders, which are wormed inside, the ores, minerals, and other stuffs are dressed and sorted, and fall out underneath the machine from the cylinders in heaps. A constant flow of water is requisite to run through the cylinders when the machine is at work.

19. Working Model, in wood and metal, of a New Ore and Coal Washing Machine.

Lent by Mr. H. E. Taylor, Engineer, 15, Newgate Street, and Sandycroft Foundry, Chester. 1878.

Note.—A series of sieves shaken by eccentric wheels revolving upon horizontal over-head shafts supported by the heavy wood framing of the machine, and working in a constant flow of water, constitute the method adopted in this apparatus for washing ore or coal. The machine is driven by steam, water, or horse power.

20. Model. Mine Head-Stock. A working model illustrating King's Patent Safety Hooks and Grips for the Cages.

Lent by Mr. Stephen Humble, Engineer, 61, Uttoxeter New Road, Derby. 1879.

Note.—King's Patent Safety Self-detaching Hooks are for preventing the possibility of overwinding the cages, and the grips are designed for sustaining them at any point in their ascent and descent in the mine shaft.

The model is on a scale sufficiently large to demonstrate clearly the action of these patent safety hooks and grips.

21. Model of a Rock Drill. Working Model of Jordan's Patent Dead-blow Hand-power Rock Drill or Boring Machine. Used for mines, quarries, and harbour works.

Lent by Messrs. Jordan, Son, and Meihé, 63, Queen Victoria Street, E.C. 1879.

Note.—Jordan's Patent Hand-power Rock Drill for rock boring purposes claims a special advantage of efficiency and utility by reason of manual labour only being sufficient to work it effectually. With the model is exhibited a coloured

drawing, showing a sectional elevation and other detail of this hand-power rock drill.

Miners' Lamps.

22. Miners' Lamp. A Davy Lamp, fitted with a Blue Glass.

Lent by Mr. A. L. Steavenson, Durham. 1879.

Note.—The exhibitor claims an advantage for his application of a piece of blue glass to a Davy miner's lamp when examining a mine, on the plea that according to the laws of absorbtion of coloured rays the glass renders the blue flame more plainly visible when gas is present in a mine.

Note on Miners' Safety Lamps.

Safety Lamps.—Miners'. Were invented 1815 by Sir Humphry Davy, the celebrated chemist and physicist, born 1778, died 1829. The names of Dr. Reid Clanny of Sunderland 1817, George Stephenson 1815, and others, are notably connected with the invention of miners' safety lamps.

See also Part II., page 152.

CLASS VII.

Machines not comprised in the foregoing Classes.

HOUSEHOLD MACHINES.

1. FRUIT and VEGETABLE PARING MACHINES. Originally an American invention, about 1851. Now made by English manufacturers, one of the many being Kent and Co., Holborn.

Lent by Mr. B. Woodcroft, F.R.S. 1877.

2. FRUIT and VEGETABLE PARING MACHINE. Designed by Exhibitor as an improvement on the American Machines.

Lent by Mr. Bennet Woodcroft, F.R.S. 1878.

Note.—This machine will pare fruit (apples and the like) and vegetables (turnips and the like) in the thinnest possible manner, and complete the operation itself. Its construction and detail, however, render it too expensive a machine for commercial sale.

3. MANGLING and WRINGING MACHINE.

Designed and Patented in 1850 by the manufacturers, E. and O. Tindall, Scarborough.

Presented 1851. 1877.

Note.—This machine was one of the earliest roller mangles made, and was called the Imperial Mangling and Wringing Machine. It was exhibited at the Great Exhibition of 1851.

4. MODEL of a PATENT MANGLE. French construction.

Messrs. Hachette and Co., London and Paris.

Note.—This model represents an early form of roller mangle. It has three hard rollers, one in front forming a feed or delivery roller, the others working one on top of the other. The uppermost roller is heavily weighted by means of a box filled with any weighty materials slung to its bearings.

From Educational Collection, 1877.

5. KNIFE for Scraping Horses. H. Francis' Patent.

Lent by Mr. B. Woodcroft, F.R.S. 1877.

6. ENGLISH DOGAN, or Money Steel Yard. For weighing money. Designed by Mr. B. Martin.

Lent by Mr. B. Woodcroft, F.R.S. 1877.

7. WORKING MODEL, in metal and wood. Jackson's TEA ROLLING MACHINE. Manufactured by Exhibitors, under Kinmond's Patent.

Lent by Messrs. Marshall, Sons, and Co., Britannia Iron Works, Gainsborough. 1878.

Note.—This machine for rolling tea leaves is employed chiefly in the tea growing districts of India.

The tea leaves are fed into a fixed hopper or frame on the top table of the machine. Through a hole which can be plugged at will, so much tea leaf as can be rolled at one time is allowed to drop on to a corrugated working table below, to which is imparted a vibratory motion by the gearing attached to drive it.

The plug filling the hole in the top table is also corrugated in a peculiar manner, and the vibrations of the lower table, rubbing the tea leaves against the corrugated under-surface of the top table and plug, both being also put into motion, rolls up the tea leaves in the way shown by the accompanying sample of rolled tea.

The rolled tea drops into a receptacle for its removal, placed beneath the lower rolling table in which a trap door is arranged to open and close at pleasure.

Machines used in Trades.

TOBACCO-CUTTING MACHINES.

8. TOBACCO-CUTTING MACHINE. Wrigley's Patent; about 1842. For cutting Cavendish tobacco.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

9. TOBACCO-CUTTING MACHINE. Alfred Leigh's Patent, 1842. Leigh and Co., Makers, Manchester.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

SUGAR-CHOPPING MACHINES, MINCING, AND OTHER MACHINES.

Note.—The collection is at present without examples of this class of machinery. But see Class IX., No. 18, and Class III., No. 55, for a drawing of "sugar making" machinery.

PRESSES FOR PACKING, ETC.

10. WORKING MODEL in metal, to a scale of about ½ inch to 1 foot, of the "Boomer and Boschert" Press. For pressing hay, cloth, paper, tallow, etc.

Lent by Messrs. J. H. Ladd and Co., 116, Queen Victoria Street, E.C. 1878.

Note.—The screw press was designed and patented by Messrs. Boomer and Boschert of Magdeburg some few years since. It is a press actuated by a hand-wheel, and pall and ratchet for extra force, having a toggle arrangement giving great pressure.

CLASS VIII.

Miscellaneous Models, &c.

1. INSTRUMENT for DIVIDING and RULING the Brass MERIDIAN RINGS of Globes.—Made by Jas. Ferguson, Esq., F.R.S. (the astronomer). 1817.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

2. MACHINE for CUTTING Sections of Wood and other Vegetable Substances; for microscopical observation.

Lent by Mr. B. Woodcroft, F.R.S. 1876.

3. DISTILLING and CHEMICAL APPARATUS by W. Bitter, Bielefeld, Westphalia.

From the Paris Universal Exhibition, 1867.
Purchased. 1868.

4. MODEL of APPARATUS for raising Heavy Spherical Bodies.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

5. CAST-IRON TEST BARS. Specimens of iron bars to illustrate the forms and positions of fractures when exposed to a breaking load.

Lent by Mr. W. J. Millar, C.E., 100, Wellington Street, Glasgow, 1876.

Note.—The bars were of 36″ span, 2″ deep, and 1″ broad. The load was applied at centre of bars. Straight fractures occurred when bars broke at, or close to, centre of span; curved fractures followed when bars broke at points more or less removed from centre.

6. BESSEMER STEEL. Specimens of Bessemer Steel, crushed and bent to show the extreme toughness and tenacity of the metal.

Lent by Sir Henry Bessemer, Denmark Hill, S. 1879.

Note.—The process invented a few years ago by Sir Henry Bessemer for converting pig-iron into steel, and the many recent modifications of his method are now thoroughly well understood.

The steam engine and blowing machine play a very important part in the production of steel from iron.

The specimens of steel exhibited comprise a small gun-hoop of mild Bessemer steel crushed while in a cold state by

a steam hammer; the effect on the fibres of the steel is highly interesting. Further three cylinders of mild steel made by the Bessemer process from English pig-iron are exhibited. One of these cylinders is in a finished state, and shows the original proportions of the two others, of which one is only partially crushed and the other is entirely flattened, serving to illustrate the extreme toughness and tenacity of the steel and its capability to withstand, while in a cold state, a succession of violent blows under a 4-ton steam hammer. The mild steel exhibited has a tensile strength of 32 tons per square inch, and will elongate 30 per cent. without breaking.

Civil Engineering.

10. Model of London and its Environs. Scale 12 inches to a mile.

Lent by Mr. John Fowler, C.E., 1, Queen's Square Place, Westminster. 1876.

Note.—This model was made for the purpose of showing before Committees of the Houses of Parliament the railways existing, or in course of construction, during the year 1864; also the proposed system of the inner circle railway, comprising the Metropolitan Railway, the Metropolitan and St. John's Wood Railway, opened 1863–1874–6, and the Metropolitan District Railway, opened 1868–1874. The model will be found in the Educational Collections.

11. Model of a Portion of the Pontcysyllte Aqueduct which carries the Shropshire Union (late the Ellesmere). Canal across the River Dee, and the Vale of Llangollen.

Lent by Mr. G. R. Jebb, C.E., Chester. 1876.

Note.—This model was made under the superintendence and direction of Telford before the aqueduct was built. The aqueduct consists of 19 arches, each having a span of 45 feet; the total length is 1,007 feet, and the height from the River Dee to the surface of the water in the canal is 127 feet. The foundation stone was laid on the 25th July 1795, and the work was finished in the year 1803.

Thomas Telford, the celebrated engineer above referred to, was born at Eskdale in Dumfrieshire 1757. He died in London 1831. In 1782 Telford established himself as a civil engineer in the metropolis. In 1793 he constructed the Ellesmere Canal. From 1803–1823 Telford was employed in the execution of the Caledonian Canal. In 1826 the Menai Straits Suspension Bridge was erected; and in 1827 Telford commenced the St. Katherine's Docks, Port of London.

Innumerable other great engineering works at home and abroad owe their existence to Thomas Telford.

12. WORKING MODEL of a proposed Low Level Bridge over the Thames between Little Tower Hill on the North, and Horsleydown Stairs on the South side of the River.

Proposed by Lieutenant F. Palmer, R.N., 1876.
Lent 1878.

Note.—The plan and detail of this Low Level Bridge is founded on a design made in 1801 by General Sir Samuel Bentham. It consists primarily in the adoption of two circular basins at each shore end of the bridge large enough to contain the longest ships requiring to pass up or down the river. These basins are connected together by the bridge proper in the centre of the river, having a span of 250 feet, or two spans of 152 feet each. The roadway for the traffic passes round the basins at each end of the bridge and would afford a roadway 51 feet in extreme breadth, besides a 12-foot pathway on each side of it, whilst over the bridge proper, in the centre of the river, and connecting the two basins together, the roadway would measure 75 feet in width.

The basins or docks surrounded by the bridge are rendered accessible to the widest masted vessels by means of draw portions of the bridge opened or shut by hydraulic power. The plan of working the river navigation through the bridge as well as the traffic over it would be uninterrupted; for whilst one side of the dock was opened for the admission or exit of vessels, the opposite side would remain closed, and the traffic being directed always towards the closed portions of the bridge in crossing it would form as it were a figure of eight. The central portion of the bridge in the middle of the river would give a clear height to the navigation up and down of 6 inches in excess of London Bridge at extreme high water.

13. WORKING MODEL. Clark and Standfield's Patent FLOATING DOCK. Constructed with a view to making the Dock "dock" itself for overhaul, painting, and repair.

Lent by Messrs. Clark and Standfield, Engineers, 6, Westminster Chambers, S.W. 1879.

Note.—This model is on a scale sufficiently large to demonstrate the principles and detail of the construction of this self-docking dock. The object aimed at is to avoid the usual heeling-over process employed to clean and repair, &c. the under-water portions of floating docks. In a few words the object is thus achieved. The sides of the dock are of sufficient floating power and capacity to lift out of the water and sustain the bottom and corner ends of the dock, whilst contrarywise the bottom and corner ends similarly will sustain above water the sides of the dock. It is obvious that under either of these conditions of the dock, boats or rafts may freely pass under and about all parts of the dock which are under water when the dock is in its normal state for carrying ships, and by means of these rafts or boats workmen

can thoroughly clean, repaint, and do small repairs without heeling the dock or grounding it for the purpose. The various operations for manœuvring the dock at all times and for all purposes are effected by steam machinery and powerful steam pumps.

For other models of Floating Docks in Museum, see Catalogue of Ship Model Collection.

14. WORKING MODEL. Halpin's Floating DOCK and Sunken Ship Raising Apparatus. Sectional Model of an Iron Ship and improved bulkheads.

Lent by Mr. D. Halpin, 7, Victoria Road, Charlton, S.E. 1879.

15. WORKING MODEL. A Low Level BRIDGE with swinging or opening arches; proposed by exhibitors for the River Thames below London Bridge.

Lent by Messrs. J. and G. Rennie, Engineers, Holland Street, Blackfriars, S. 1879.

Note.—This bridge, it is proposed, should cross the Thames from Tower Hill to Queen Elizabeth Street, Surrey side. It would measure 880 feet from shore abutment to shore abutment, and all the spans, if necessary, would open to permit masted vessels passing. The fender piers seen in the model would contain the steam machinery for working the centre and second arches; the abutment arches would be worked by steam machinery on shore. The piers of the bridge would be of cast-iron filled in with cement, and the bridge itself of wrought-iron.

16. MODEL. Cunningham's Patent Wrought-iron FLOATING Swing BRIDGE.

Lent by Mr. David Cunningham, Harbour Works Office, Dundee.

Note.—This system of floating swing bridge principally employed for docks has been applied to the large caissons closing the Victoria Wet Dock and the new Graving Dock at Dundee.

17. MODEL. The Wrought-iron Tubular BRIDGE over the River Conway, at Conway, N. Wales. Built 1846 by Robert Stephenson to carry the Chester and Holyhead Railway across that river.

Lent by Mr. G. R. Stephenson, C.E., 9, Victoria Chambers, S.W. 1879.

Note.—This celebrated tubular bridge was built by the late Robert Stephenson, C.E., in 1846, to carry a double line of railway over the River Conway for the extension of the London and North-western Railway system, by the Chester and Holyhead line, to Holyhead, in the island of Anglesea. The span of the bridge is 400 feet, and it is in one length,

without any central pier or support. The model was made for Mr. R. Stephenson by S. Salter, Hammersmith. The scale of it is $\frac{3}{4}$ inch to 10 feet.

The celebrated wrought-iron Britannia tubular railway bridge over the Menai Straits, which may be said to be the contemporary of the Conway tubular bridge, was constructed 1846–1850 under Mr. Robert Stephenson and Mr. William Fairbairn, engineers. Each tube (there are four) of this bridge is above a quarter of a mile long.

18. ROOF CONSTRUCTION. Model in Wood and Iron, illustrating Holt's Principle for Roofs. Fifty feet span.

Lent by Mr. H. P. Holt, 4, Westminster Chambers, S.W. 1879.

Note.—This model represents Mr. H. P. Holt's method of trussing roof principles of iron and wood.

19. MEASURING INSTRUMENT. Measuring the $\frac{1}{4,890}$th part of an inch. Designed by Mr. Chappé for experiments conducted by Mr. W. H. Barlow, C.E.

Lent by Mr. T. F. Chappé, 29, Stanley Gardens, Notting Hill. 1879.

Note.—This micrometer or measuring instrument was designed for and used in experiments made to determine the position of the neutral axis in beams.

20. Coloured DRAWING. Design for a CAST-IRON RIB. For underground groining. (Arch or vault work.)

Lent by Mr. J. H. Watson Buck, C.E., Crick, Northampton. 1879.

21. PARALLEL MOTIONS. Two Working Models in Brass. Hart's 5-Bar Parallel Motions. Designed and constructed by Exhibitor.

Lent by Mr. Harry Hart, Royal Military Academy, Woolwich. 1879.

23. PATENT PAINT. Eighteen specimens of, on a board. For painting machinery, ironwork, wood, stone, brick, and cement work, etc. Gay's Patent.

Lent by R. Gay and Co., Manufacturers, Crescent House, Vauxhall Bridge Road, S.W. 1878.

FIRE ARMS.

25. DOUBLE-BARREL Breech-loading PISTOL. Delvigne's Patent; about 1848.

Lent by Mr. B. Woodcroft, F.R.S. 1877.

Note.—Pistols, the smallest of fire-arms, were originally invented at Pistoia in Italy, and were first used by the

Cavalry of England in 1544. Pistols were first made in England by machinery, introduced from America 1853, by Colonel Colt, who also brought out the first "revolver" pistol in 1851. The Government Factory at Enfield for the manufacture of military rifles and small arms by machinery, was started in 1851.

26. OLD FOWLING PIECE; with early action; probably match-lock.

Lent by Mr. B. Woodcroft, F.R.S. 1877.

Note.—Fire-arms were first made at Perugia in Italy, in 1364. Match-locks and wheel-locks for discharging fire-arms, were superseded by the flint-lock, 1692. The percussion action for fire-arms was invented by the Rev. Mr. Forsythe in 1807.

The army percussion musket was adopted in 1842.

Rifled arms, army pattern, adopted, 1851.

The Snider breech-loading military rifle invented, 1859.

The Chassepot rifle adopted in France, 1866.

The present Martini-Henry military rifle adopted, 1869.

Cannons were used by the Turks at the seige of Adrianople in 1453.

The first cannons cast in England were made by Hugget, at Uckfield in Sussex; 1543.

Rifled cannon adopted, 1859.

Breach-loading rifled guns were adopted in same year, 1859.

Palliser chilled shot and shell for heavy guns invented and tried, 1864.

Captain Moncrieff's elevating and disappearing plan of mounting guns in works, invented 1868.

Gunpowder is said to have been invented in Germany about 1320; but was evidently known at an earlier date, as Roger Bacon mentions it. He died 1292–4.

Gunpowder was first used by the English army 1346.

Pellet powder adopted for heavy guns 1868.

Gun-cotton invented 1846 by Prof. Schönbein of Basle.

27. CHINESE Military HELMETS (2). Made of steel.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

28. CHINESE Military HELMETS (2). Made of cane.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

CLASS IX.

Drawings and Photographs.

MACHINE DRAWINGS.

1. WORKING DRAWING, $\frac{1}{3}$ actual size, or 4 inches to 1 foot.

Sheave or Pulley. For a hoisting crane.
Side and end elevations.
Two through sections.

2. WORKING DRAWING, $\frac{1}{2}$ actual size, or 6 inches to 1 foot.

Spur Wheel.—Tooth wheel, for gearing.
Side elevation, showing method of laying out pitch of tooth and tooth circle.
Section of arm of wheel.
Section through centre of wheel.
Plan of wheel.

3. WORKING DRAWING, $\frac{1}{3}$ actual size, or 4 inches to 1 foot.

Mitre Wheel.—Gear wheel.
Showing plan, elevation, and sections of wheel.

4. WORKING DRAWING, $\frac{1}{12}$ actual size, or 1 inch to 1 foot.

Eight feet cast-iron Fly-wheel.
Side elevation, with part of rim in section.
End elevation. Three through sections.

Note.—The wheel is cast in two segments, and united by wrought-iron hoops, shrunk on the boss and by dowels and cotters at the rim.

5. WORKING DRAWING, $\frac{1}{4}$ actual size, or 3 inches to 1 foot.

Cast-iron Engine Crank.
Side elevation. Plan throughout.
Plan when turned $\frac{1}{4}$ of a revolution.
Section through firm and web.
A longitudinal through section, and a section when turned $\frac{1}{4}$ of a revolution.

6. Working Drawing, ⅓ actual size, or 4 inches to 1 foot.

Connecting Rod End, for a 25 horse-power steam engine.

Elevation. Plan. Two sections.

7. Working Drawing, of the Governor of a Steam Engine.

Front and side elevation.

Elevation and plan of Slide.

Pendulum Rod, showing Ball in section, and method of attachment.

Elevation and plan of forked rod.

Section through slide.

The front and side elevations are ¼ real size, or 3 inches to 1 foot.

The details are ½ real size, or 6 inches to 1 foot.

8. Working Drawing, ½ full size, or 6 inches to 1 foot.

Pillar Block, Plummer Block, or Pedestal; for a 4½-inch shaft or journal.

Side elevation.

End elevation. Plan. Sheet No. 1.

9. Working Drawing, on a ½ scale, or 6 inches to 1 foot.

Pillar or Plummer Block for a 4½-inch shaft or journal.

Various sections. Sheet 2.

10. Working Drawing, on a ¼ scale, or 3 inches to 1 foot.

Hanging Bracket and Pillow Block, for a 3½-inch shaft; attached to a 16-inch Cast-Iron Girder.

Front and side Elevations.

11. Working Drawing, full size. Steam Whistle.

Elevation. Plan. Sections.

The vertical section shows by arrows the passage of the steam through the whistle.

12. Working Drawing, on a ¼ scale, or 3 inches to 1 foot.

Moveable Head-stock for a Turning lathe.

Side elevation, plan, and section.

End elevation and section.

13. WORKING DRAWING, full size.
Water cock or Tap.
Side elevation. End elevation.
Plan. Side and end elevation of plug.
Through section of Tap.

14. WORKING DRAWING, $\frac{2}{3}$ full size, or 8 inches to 1 foot.
Stop-cock or Straightway Cock, for steam or water.
End elevation. Side elevation. Plan. Two sections.
The preceding 14 Working Drawings (Lithographs) of Parts of Machinery and Steam Engines are published by Thomas Busbridge, 41, Frederick Place, Plumstead, S.E.

15. DRAWING, Coloured; $\frac{1}{5}$th actual size, of a Centrifugal Drying Machine: showing various modes for driving same.
Presented by Mons. N. Fouquemberg, Constructor, Husseigneis, Ath, Belgium. 1871.

16. DRAWING, $\frac{1}{8}$ full size or $1\frac{1}{2}$ inches to 1 foot, of an Improved Ship's Steam Winch.
Presented by Messrs. Alexander Chaplin and Co., Engineers, Glasgow. 1874.

17. DRAWING, on a scale of 1 inch to 1 foot, of Steamships' Winding Engine, with Distilling Apparatus for Fresh water, and Steam Cooking Hearth.
Presented by Messrs. Alexander Chaplin and Co., Engineers, Glasgow. 1874.

18. DRAWING, Coloured. Sugar-making Machinery. Engine and Boiler House, Cane-crushing Mill, Juice Boiling House with vacuum pans and complete plant for producing raw or brown sugar. 1878.

Note.—The Drawing is lettered throughout and has a full printed description of the general process of Sugar-making.
See also Page 103.

19. DRAWING, Coloured; of a Naval Service Turret Carriage for a 35-ton "Woolwich" rifled muzzle-loading Gun. Showing the position and arrangement of the steel trunnion blocks, and hydraulic elevator. Scale, 3 inches to 1 foot.
Presented by the War Department. 1873.

Note.—The carriage and platform, of wrought iron, were designed and constructed in the Carriage Department, Royal

Arsenal, Woolwich. The steel castings for the trunnion blocks were made by Messrs. Vicars and Co., Sheffield.

The drawing shows longitudinal elevation of the gun, carriage, and part of platform. A portion of the carriage bracket is removed to show trunnion block.

A sectional elevation through trunnion block.

*** *This Drawing will be found in the collection of Munitions of War.*

20. DRAWING of the Wrought-iron Girder Lattice Bridge on the Pacasmayo, Guadaloupe, and Magdalena Railway, Spain.

Lent by W. Willis. 1876

Note.—The bridges were designed for 50 feet spans by Mr. Edward Woods, C.E., 1872. The drawing shows a general elevation of the bridges, half elevation of girders, and details of their rolling end, plan of flooring, and other details. These Drawings were photographed from the originals and printed by Mr. Willis' Patent Aniline Process.

21. DIAGRAMS on Cloth of Applied Mechanics and Machines; for lecture purposes.—Coloured.

Lent by Mr. F. J. Bramwell, F.R.S. 1876.

Note.—Fig. 41. Modern traction engine for agricultural purposes.

Fig. 42. R. W. Thompson's traction engine, the wheel tyres of which are composed of india-rubber overlaid with steel shoes in a transverse direction.

Fig. 44. Modern steam Fire-engine. Constructed by Merryweather and Co.

Fig. 46. Outline drawing of Stephenson's locomotive engine "Rocket," 1828.

Fig. 45. An early locomotive with vertical engines of the type of "Puffing Billy," 1812; George Stephenson's No. 1, 1825.

Fig. 43. Hancock's patent steam carriage for common roads. 1826.

Fig. 19. A Cornish pumping engine of modern construction.

22. DRAWINGS, COLOURED, 16 in number. Illustrating on a large scale Machine Work, Building Construction, &c. Prepared by Professor Unwin and others for the instruction of students in Science Schools and Classes.

Exhibited by the Science and Art Department. 1877.

Note.—These drawings forming part of a series used in science schools and classes under the Science and Art Department for the instruction of students in the principles and practice of mechanical and civil engineering, are published by Messrs. Chapman and Hall, Piccadilly.

23. Drawings, Coloured. 6 in number. Steam Engine Detail. Prepared by Professors Goodeve and Shelley for the instruction of Students in Science Schools and Classes.

Exhibited by the Science and Art Department. 1877.

Note.—These drawings forming part of a series used in science schools and classes under the Science and Art Department for the instruction of students in mechanical engineering are published by Messrs. Chapman and Hall, Piccadilly.

24. Drawings, Coloured. 3 in number. Steam Engine Governors, Boiler Feed Pumps, and other Detail. Prepared by Professors Goodeve and Shelley for the instruction of Students in Mechanical Engineering in Science Schools and Classes under the Science and Art Department.

Exhibited by the Science and Art Department 1877.

Note.—These drawings forming part of a series are published by Messrs. Chapman and Hall, Piccadilly.

25. Drawing and Photograph, Coloured. Air Compressing Engines on the system of Professor Colladon of Geneva.

Presented 1876.

Note.—This drawing and photograph represents the steam engine and pumps for compressing air and supplying it to the various operations carried out in the construction of the railway tunnel through Mont Cenis on the railways connecting the systems of France and Italy.

26. Drawings.—Three Cartoons; on linen. Showing general Plan, general Section, and Timber Stageing used in erecting the Roof of St. Pancras Station.—The terminus in London of the Midland Railway.

Lent by W. H. Barlow, C.E., High Combe, Charlton, S.E., Kent.

Note.—These drawings illustrate on a large scale the following details of this terminus of the Midland Railway in the Euston Road, London.

1. General plan of station.

2. General section; scale ½ inch to 1 foot. Detail of ribs ¾ full size. Detail of roofing ¾ full size. The drawing of the general section of St. Pancras station shows detail of the underground work, the flooring and roofing, and an enlarged section of one rib, showing mode of connection with the purlins. Also an elevation of part of one rib showing the method of carrying the sash-bars and ventilators of the roof.

3. The timber stageing in elevation; used by the contractors in erecting the roof.

The clear span of the station roof is 240 feet. The distance between side walls 245 feet 6 inches. The area

of ground covered by the roof, 169,400 square feet. The number of masonry columns in the basement supporting the flooring is 720. The contractors for the iron work and the erection of the station were the Butterly Iron Company, Staffordshire. The station was opened in 1869, and attached to it is an hotel of Gothic design and detail in red and white bricks, stone dressings, and marble and terra-cotta ornaments, by the late Sir Gilbert Scott, R.A. The hotel was opened in 1873–74.

27. PEN AND INK DRAWING. Design for Harbour and Docks at Newhaven. F. D. Bannister, M.I.C.E., Engineer.

Lent by the London, Brighton, and South Coast Railway Company. 1878.

Note.—These works at Newhaven are now in course of construction and completion. 1879.

28. RELIEF MAP. Scale 25 inches to 1 mile. The Thirlmere Lake, and district around; being the proposed source of water supply to the city of Manchester. 1876–79.

Lent by Mr. J. F. Bateman, C.E., F.R.S., Great George Street, Westminster. 1879.

Note.—Thirlmere Lake, one of the smaller lakes in the English Lake District of Cumberland, has long been viewed favourably as a source of water supply to Manchester. It will be seen that the existing out-flow of the lake, as shown on the relief map, will have to be stopped up, and the water of the lake forced to take a contrary direction to its present flow. There will be found in the Museum eight large maps hung, four of which trace the proposed course of the aqueduct to be built, about 96 miles, to bring the water of Thirlmere to Manchester. The other four maps give sectional elevations of the country to be traversed by the aqueduct as well as the varying levels and arrangements of it. The relief map was constructed under Messrs. Brockbank, Wilson, and Mulliner, engineering surveyors, Manchester. Mr. J. F. Bateman, F.R.S., is the engineer to this undertaking.

29. RELIEF MAP. The SUEZ CANAL. From Port Said, Mediterranean, to Suez on the Red Sea.

A reproduction after the original drawings by Admiral Paris, Director of the Museum of Marine at Paris. By M. C. Muret.

Lent by Colonel Sir John Stokes, R.E., K.C.B., Chatham. 1879.

Note.—This relief map is on a scale of $\frac{1}{100,000}$th (0·001 per 100 m.) for the horizontal distances, and $\frac{1}{20,000}$th (0·001 per 20 m.) for the elevations. The map was executed by M. Ch. Delagrave, 58, Rue des Ecoles, Paris, 1876. The present Suez Canal is cut through 90 miles of sand. It was

projected in 1852 by the French engineer, M. de Lesseps. The actual works were begun 1858–59 under his direction, and the Canal was first traversed by a boat in 1865. The first ship, 80 tons burden, passed through from sea to sea in 1867. The canal is now passed by some of the largest ships in Her Majesty's Navy, and of the commercial world. A canal connecting the Mediterranean and Red Seas is supposed to have been made by Necho, 600 B.C. Restored by Trajan in the 2nd century, and finally blocked by sand, A.D. 767.

Photographs of Machinery.

35. SERIES of PHOTOGRAPHS, illustrating Steam Machinery manufactured by Messrs. Alexander Chaplin and Engineers, Glasgow.

Photograph of a Steam Winding and Pumping Engine.

Photograph of a Steam Travelling Crane.

Photograph of a Single Cylinder Hoisting Engine.

Photograph of a Winding and Pumping Engine.

Photograph of a Steam Fresh Water Distilling Engine, on Travelling Carriage.

Photograph of a Contractor's Locomotive Engine.

Presented by Messrs. Alexander Chaplin and Co., Cranston Hill Engine Works, Glasgow. 1874.

36. PHOTOGRAPH of The New Factory in the Royal Carriage Department, Woolwich Arsenal, 1873.

Presented by the War Department. 1874.

37. PHOTOGRAPH of the 38-ton Nasmyth Steam Hammer, erected 1874 in the Gun Factory, Royal Arsenal, Woolwich. By Messrs. Nasmyth and Co., Glasgow.

Presented by the War Department. 1874.

38. PHOTOGRAPH of an Hydraulic Lifting Crane, in the Royal Arsenal at Woolwich.

Presented by the War Department. 1874.

39. PHOTOGRAPH of New Factory, Royal Gun Factories, Woolwich Arsenal, showing new 38-ton Nasmyth Steam Hammer, erected in 1874; and New Furnaces, for large heats. Presented by the War Department. 1874.

40. PHOTOGRAPH of a 38-ton "Woolwich" Gun; and a 7-pounder "Abyssinian" Mountain Gun; in workshop at Royal Arsenal, Woolwich.

Presented by the War Department. 1874.

Note.—The preceding 5 photographs presented by the War Department will be found in the collection of Munitions of War.

41. PHOTOGRAPH. Representing the entire range of buildings, the Gasworks, the Brick-making Yards, &c., connected with Krupp's Steel Works at Essen, Prussia. 1866.

Presented by Mr. B. Woodcroft, F.R.S. 1877.

Note.—This photograph, mounted on canvas and on a large scale, represents exterior views of the entire establishment owned by Messrs. Krupp and Co., and forming their renowned steel foundry and works at Essen, Prussia, as they stood in 1866.

PART II.

Models of Mechanism. Belgian Manufacture.

Illustrating:—

1. CAPSTAN; with Levers for working it. (Wood model.)
Belgian Government. 1871.

2. AN ORDINARY CRANE, Belgian form. (Wood model.)
Belgian Government. 1871.

3. PILE DRIVING MACHINE; for manual power. (Wood model.)
Belgian Government. 1871.

4. SERIES OF PULLEYS; and their Mechanical combinations. (Wood models.)
Belgian Government. 1871.

5. A WINDLASS with Crank handles. (Wood model.)
Belgian Government. 1871.

6. CUSTOM HOUSE PLUMBING MACHINE. Belgian. Used for plumbing with lead seals merchandise and baggage.
Belgian Government. 1871.

7. MINER'S SAFETY LAMP. Actual size. A. Goebel's Patent.
Belgian Government. 1871.

Note.—These models were presented by the Belgian Government to the Museum 1871, and form part of the Educational Collections, from which they were transferred. 1877.

Models of Mechanism. French Manufacture.

HACHETTE and Co. London, King William Street, Strand, and Paris.

Illustrating:—

1. TWO CAPSTANS with levers. (Wood model.)
Hachette and Co.

2. CENTRIFUGAL MOTION; Model Machine to illustrate the force of.
Hachette and Co.

3. A Butter Churn; upright churn with rocking beam motion. (Wood model.)
Hachette and Co.

4. Ordinary Escapement; for a Clock.
Hachette and Co.

5. Wood Model showing the Conversion of Circular into Reciprocating Motion. Vertical and horizontal motions.
Hachette and Co.

6. Model, in Wood. Cam Motion with Stops. The vibrating bar driven by friction rollers.
Hachette and Co.

7. Models, in Wood. Two common Cranes. French form. The windlass worked by levers.
Hachette and Co.

8. Model, in Wood. Crane, with Independent Windlass to be worked by crank handles. French form.
Hachette and Co.

9. Model, in Wood. Crane with Wheel and Axle, windlass, and radiating jib. French form.
Hachette and Co.

10. Detent Movement. (Model, in Wood.)
Hachette and Co.

11. Driving Clutch for shafts. (Model, in Wood.)
Hachette and Co.

12. Face and Lantern Wheel. (Model, in Wood.)
Hachette and Co.

13. Flattening or Rolling Machine. (Model, in Wood.)
Hachette and Co.

14. Flour Bolting Machine. (Wood Model.)
Hachette and Co.

15. Model, in Iron, of a Fly-Wheel.
Hachette and Co.

16. Set of Forge Hammers worked by Cam motion. (Model, in Wood.)
Hachette and Co.

17. Hooke's Coupling or Universal Joint. (Model, in Wood.)
Hachette and Co.

18. WORKING MODEL. A LIFTING JACK. Screw Jack. French form.
Hachette and Co.

19. TWO STONEMASON'S LEVELS. (Models.)
Hachette and Co.

20. MICROMETER Measuring Machine.
Hachette and Co.

21. MODEL, in Wood; HEAVY PILE DRIVER—for manual power, with independent windlass. French form.
Hachette and Co.

22. TWO COMMON PILE DRIVERS—The monkey to be worked by manual power. French form. Wood models.
Hachette and Co.

23. SET OF PULLEYS, and their combinations. Model, in Wood.
Hachette and Co.

Note.—The Pulley, Vice, and other similar mechanical instruments are said to have been invented by Archytas of Tarentum, about 400 B.C., or, by Archimedes, about 287—212 B.C.

24. TWO MODELS, in Wood. Wheel and Axle Windlasses, used in stone quarries. French form.
Hachette and Co.

25. THE SCREW. Two Models, in Wood.
Hachette and Co.

Note.—The screw was known to the Ancient Greeks. Archimedes, the Greek Philosopher B.C. 287–212, invented his pumping screw, 236 B.C. It is said that by means of the screw, one man can press down or raise up as much as 150 men can do without it.

26. MODEL, of the ARCHIMEDEAN SCREW, in Glass. For raising water.
Hachette and Co.

27. MODEL, in Metal. A Four-blade SCREW PROPELLER FOR SHIPS.
Hachette and Co.

28. MODEL, in Wood. Ore or Seed Stamping Machine. The Stamps worked by pegs.
Hachette and Co.

29. WOOD MODEL, of a Friction Dynamometer.
Hachette and Co.

30. STEAM-ENGINE MODELS. Two sectional working models, in pasteboard, of Watt's Condensing Engine.
Hachette and Co.

31. WORKING MODEL, complete, with Boiler, &c. Vertical or upright Steam-Engine. The cylinder of glass, to show the working of the piston.
Hachette and Co.

32. MODEL, in Iron. Pair of Bevel Wheels.
Hachette and Co.

33. MODEL, in Iron. Spur wheel, and Screw.
Hachette and Co.

34. WOOD MODEL. Toothed-wheel and Pinion.
Hachette and Co.

35. TWO MODELS, in Wood. Of Ordinary Windlasses.
Hachette and Co.

36. SKELETON MODEL, in Wood, of a Windmill. A post mill. French form.
Hachette and Co.

Note.—This model is a working model, and shows the driving gear for one pair of stones, a flour bolting machine, and hoist.

36*a*. WOOD MODEL of the Driving gear of a Pair of Mill Stones.
Hachette and Co.

37. MODEL, in Wood. A miner's Lift and Ladder, worked by eccentrics.
Hachette and Co.

38. WOOD MODEL. Apparatus for demonstrating the laws of Friction and Gravitation.
Hachette and Co.

39. A COMPENSATING PENDULUM for a clock. The actual form and construction.
Hachette and Co.

40. A SET of Collision Balls. On a stand.
Hachette and Co.

41. PAIR OF LEVERS, in Brass. Balance for scales. Working on knife-edged centres of steel.
Hachette and Co.

42. Spring Weighing Machine. French pattern. Lebreton's patent.

Hachette and Co.

43. Models, in Wood. 5 Water Wheels.

Hachette and Co.

43*a*. Overshot Water Wheel.

Hachette and Co.

43*b*. Undershot Water Wheel.

Hachette and Co.

43*c*. Undershot Water Wheel with parabolic buckets.

Hachette and Co.

43*d*. Bucket Wheel for raising water.

Hachette and Co.

43*e*. Scoop Wheel, for raising water.

Hachette and Co.

44. Three Working Models of Lift Pumps. The barrels of glass, the levers in brass, the plunger and rod glass and metal.

Hachette and Co.

45. Model, in Wood. Chain Pump; ordinary form. Vertical action.

Hachette and Co.

46. Model, in Wood. Chain Pump with Buckets. Vertical action.

Hachette and Co.

47. Two Models, in Wood. Chinese Chain Pumps. Horizontal action.

Hachette and Co.

48. Working Model of a Portable Fire-Engine. French construction.

Hachette and Co.

49. Working Model of Bramah's Hydraulic Press.

Hachette and Co.

Note.—These models (pp.152–156) by Hatchette and Co., of Paris and London, were acquired in 1857.

Transferred from Educational Collection, of which they form part. 1877.

SECTIONAL WORKING MODELS IN CARDBOARD OF STEAM-ENGINES. FRENCH MANUFACTURE.
Salleron and Co., Paris.
Purchased 1857.

50. WORKING MODEL of Watt's Condensing Beam Engine.
Salleron, Paris, 1857.

50*a*. SECTIONAL MODEL. Paddle-wheel Side-lever Marine Engine.
Salleron, Paris, 1857.

50*b*. WORKING MODEL. Crampton's Locomotive Engine For high speed train service.
Salleron, Paris, 1857.
Transferred from the Educational Division, 1877.

Models of Mechanism. German Manufacture.

MODELS in Iron and Wood. For Technical Instruction in machinery, mechanics, architecture, building construction, and brickwork. The formation and erection of smelting and other furnaces for manufacturing purposes.
Made by J. Schroeder, and Pupils, Darmstadt. 1867.

Note.—The numbers in brackets correspond with those in Mr. Schroeder's price list.

Transferred from Educational Division, 1877.

1. CAST-IRON Working Model; illustrating Differential wheel Motion.
Schroeder, Darmstadt.—(450.)

2. CAST-IRON Working Model. "Heart." Toothed Wheels; producing variable velocity.
Schroeder, Darmstadt.—(460.)

3. CAST-IRON Working Model. Parallel Reciprocating Motion with wheel and rack-work.
Schroeder, Darmstadt.—(487.)

4. CAST-IRON Working Model. Ratchet Motion with detent.
Schroeder, Darmstadt.—(508.)

5. CAST-IRON Working Model. Ratchet Motion with pallet and detent.
Schroeder, Darmstadt.—(510.)

6. CAST-IRON Working Model. Variable Ratchet Motion with pallet and detent, slide bar, block and set-screw for adjusting the stroke. "Clement's Pallet or Driver."
Schroeder, Darmstadt.—(509.)

7. CAST-IRON Working Model. Reversing Motion. Bevel wheel gearing, driving strap, rigger and pulleys.
Schroeder, Darmstadt.—(513.)

8. CAST-IRON Working Model. Reversing Motion. Differential bevel wheel gearing, driving strap, pulleys and rigger.
Schroeder, Darmstadt.—(514.)

9. CAST-IRON Working Model. Governor for Water Wheels. Compound lever governor (Watt's and Hughes') with clutch reversing motion.
Schroeder, Darmstadt.—(525.)

10. CAST-IRON Working Model. Toothed Wheel Gearing. Differential speed.
Schroeder, Darmstadt.—(440.)

11. CAST-IRON Working Model. Bevel Wheel Gearing. Differential speed.
Schroeder, Darmstadt.—(441.)

12. CAST-IRON Working Model. Screw and Spur Wheel Motion.
Schroeder, Darmstadt.—(215.)

13. CAST-IRON Working Model. Shaft Motion. Bevel wheel gearing with clutch for reversing and stopping.
Schroeder, Darmstadt.—(521.)

14. CAST-IRON Working Model. Friction Dynamometer.
Schroeder, Darmstadt.—(181.)

15. CAST-IRON Working Model. Rigger and Pulley; showing cross strap motion.
Schroeder, Darmstadt.—(759.)

16. CAST-IRON Working Model. Rigger and Pulley showing open strap motion.
Schroeder, Darmstadt.—(763.)

17. CAST-IRON Working Model. Crank Motion.
Schroeder, Darmstadt.—(479.)

18. Cast-Iron Working Model. Engine Beam. Centre beam with parallel motion.
Schroeder, Darmstadt.—(495.)

19. Cast-Iron Working Model. Engine Beam; vibrating beam, with parallel motion.
Schroeder, Darmstadt.—(496.)

20. Cast-Iron Working Model. Marine Engine Beam; side lever, with James Watt's parallel motion.
Schroeder, Darmstadt.—(498.)

21. Cast-Iron Working Model. Reciprocating Motion by spur gearing.
Schroeder, Darmstadt.—(482.)

22. Model of an Overshot Water Wheel of Iron, Drum-wheel, with parabolic buckets.
Schroeder, Darmstadt.—(537.)

23. Model of an Undershot Water Wheel. Breast-wheel. Iron arms or spokes with wooden buckets.
Schroeder, Darmstadt.—(536.)

25. Working Model, in Wood. Wall Bracket or Bearing for shafts.
Schroeder, Darmstadt.—(715.)

26. Working Model, in Wood. Wall Bracket or Bearing for shafts; with adjusting screw to brasses.
Schroeder, Darmstadt.—(722.)

27. Working Models, in Wood. Hanging or pendent Brackets for driving shafts. (Two.)
Schroeder, Darmstadt.—(304 and 721.)

28. Working Models, in Wood. Adjustable pendent Brackets for driving shafts. (Two.)
Schroeder, Darmstadt.—(716 and 717.)

29. Working Model, in Wood. Wall Brackets or Bearings for shafts; showing wall plate, cast-iron bearing, brasses, bolts and nuts, and other details.
Schroeder, Darmstadt.—(722 and 715.)

Note.—No. 722, the brasses are adjusted by a set screw. And 715 the brasses are adjusted by a wedge.

30. WORKING MODELS, in Wood. Bearing or Plummer Block for shafts. (Two.) With foot-plate, showing brasses, bolt and nut connections, oil hole and other details. The block adjusted on bed-plate by wedges and packing.
Schroeder, Darmstadt.—(713 and 302.)

31. WORKING MODEL, in Wood. Foot-plate; (step) for upright shafts. Showing bed-plate, bolts and nuts, brass bearings, and adjustment by wedges and packing.
Schroeder, Darmstadt.—(714.)

32. WORKING MODEL, in Wood. Driving Clutch Coupling for shafts, the ends butt.
Schroeder, Darmstadt.—(311.) ? 301.

33. WORKING MODEL, in Wood. Driving Clutch for shafts. Disc and Fork Clutch.
Schroeder, Darmstadt.—(41.)

34. WORKING MODEL, in Wood and Iron. Bridge or Girder Foundation, for horizontal and vertical shaft motion.
Schroeder, Darmstadt.—(799.)

35. WORKING MODEL, in Wood. Section of a Spur Wheel; showing part of arm, rim, and teeth.
Schroeder, Darmstadt.—(736.)

36. WORKING MODEL, in Wood. Section of a Spur Wheel; showing part of boss, rim, and teeth.
Schroeder, Darmstadt.—(739.)

37. WORKING MODEL, in Wood. Section or portion of a Mortice Spur Wheel; showing part of arms, and rim, and wooden teeth.
Schroeder, Darmstadt.—(744.)

38. WORKING MODEL, in Wood. Section of a Bevel Wheel; showing arm, part of nave or boss, rim and teeth.
Schroeder, Darmstadt.—(752.)

39. WORKING MODEL, in Wood. Section of a Bevel Wheel Pinion; showing arm, part of nave or boss, rim and teeth.
Schroeder, Darmstadt.—(751.)

40. WORKING MODEL, in Wood. Engine Beam, Cast-Iron.
Schroeder, Darmstadt.—(838a.)

41. Working Model, in Wood. Piston-rod Crosshead and Slide Blocks.
Schroeder, Darmstadt.—(880.)

42. Working Model, in Wood. Forked Piston-rod Head, with slide blocks and attachments.
Schroeder, Darmstadt.—(882.)

43. Working Model, in Wood. Piston-rod Head, with vertical guide blocks.
Schroeder, Darmstadt.—(344.)

44. Working Model, in Wood. Piston-rod Head; fitted to single horizontal guide. Showing detail of attachment and adjustment. Bolts and nuts for guide and other details.
Schroeder, Darmstadt.—(888.)

45. Working Models, in Wood. (Two.) Connecting-rod Heads and attachments, for engine connecting-rods.
Schroeder, Darmstadt.—(337 and 845.)

46. Working Models, in Brass. (Two.) Stuffing Boxes and their details.
Schroeder, Darmstadt.—(923-924.)

47. Working Model, in Wood. Eccentric Wheel. Showing strap, lubricator, bolt and nut adjustments. The wheel cast in two halves and held together by bolts, keys, and cotters.
Schroeder, Darmstadt.—(317.)

48. Working Model, in Wood. Engine Crank; cast-iron, with part of shaft. The crank is keyed to shaft by steel key and sunk key-ways. The crank-pin held in place by pin through crank head.
Schroeder, Darmstadt.—(313.)

49. Working Models, in Wood. (Two.) Crank Axles; wrought iron; single cranks.
Schroeder, Darmstadt.—(314 and 315.)

50. Working Models, in Iron. (Two.) Screw, Gas and Steam Pipe-Joints.
Schroeder, Darmstadt.—(360 and 361.)

51. Working Model, in Wood. Flange Joint for steam pipes; showing flanges with faced joints, bolt and nut connections.
Schroeder, Darmstadt.—(364.)

52. WORKING MODEL, in Wood. Stop Cock. Flanged ends for joints.

Schroeder, Darmstadt.—(366.)

53. WORKING MODELS, in Wood and Iron. Bolt and Nut Joints; (10 pieces); for cast-iron tanks; wrought-iron plates; valve boxes; and other purposes.

Schroeder, Darmstadt.—(770 to 677.)

54. MODELS, in Wood and Iron. Bolt and Nut, and Tie-Rod Connections. 16 illustrations on a board.

Schroeder, Darmstadt.—(652 to 669.)

Note.—Used for iron, wood, and stone, work.

55. WORKING MODEL, in Wood. Bed Plate Foundation.

Schroeder, Darmstadt.—(809a.)

56. WORKING MODEL, in Wood and Metal. Foundation. Upright shafting, showing foot-plate (step). Steadying collar, and flanged coupling.

Schroeder, Darmstadt.—(.)

57. WORKING MODEL, in Wood. Equilibrium Valve.

Schroeder, Darmstadt.—(917.)

58. WORKING MODELS, in Wood. (Eight.) Axles for Water Wheels. Representing plain axles, shoulder axles, axles for hexagon (wheel) bosses, and axles with stiffening pieces or trusses.

Schroeder, Darmstadt.—(697–704.)

59. WORKING MODELS, in Wood. (Seven.) Axles for Water Wheels similar to the above.

Schroeder, Darmstadt.—(287–293.)

60. WORKING MODEL, in Wood. Crane Hook with swivel.

Schroeder, Darmstadt.—(341.)

61. WORKING MODEL, in Wood. Double Crane Hook, with swivel.

Schroeder, Darmstadt.—(342.)

62. MODELS, in Wood. (Nine Pieces.) Architectural Bases for columns. Corinthian, Ionic, Doric, Gothic, and other styles of architecture.

Shroeder, Darmstadt.—(9.)

63. MODEL of Roof Construction. A trussed roof, high pitch.

Schroeder, Darmstadt.—(.)

64. Model of Roof Construction. A trussed roof, low pitch.

Schroeder, Darmstadt.—(.)

65. Model of the Wooden Roof of the Townhall, Darmstadt.

Schroeder, Darmstadt.—(.)

66. Model of the Roof over the Taunus Railway Station, Frankfort on the Maine.

Schroeder, Darmstadt.—(.)

67. Model of the Roof over the Fruit Market at Mayence, Germany.

Schroeder, Darmstadt.—(.)

67*a*. A series of 69 Wood Models illustrating the carpenter's and joiner's work as carried out in buildings, and the construction of the Frames and Joints of Roofs, Floors, Partition Walls, Fittings, and general wood work.

Schroeder, Darmstadt.—(.)

68. Model, in Wood, showing the Furnace arrangements and Flues for a Brewing copper.

Schroeder, Darmstadt.—(2104.)

69. Model, in Wood, showing the Furnace arrangements and Flues for a Brewing pan.

Schroeder, Darmstadt.—(2106.)

70. Model, in Wood. Smithy Forge—Ground Forge—with double fires, blast, smoke-shaft, and other details.

Schroeder, Darmstadt.—(2206.)

71. Model, in Wood. Smelting Furnace.

Schroeder, Darmstadt.—(2210.)

72. Model, in Wood. Blast Furnace.

Schroeder, Darmstadt.—(2215.)

73. Model, in Wood. Blast Furnace.

Schroeder, Darmstadt.—(2214.)

74. Model, in Wood. Hungarian Blast Furnace for smelting.

Schroeder, Darmstadt.—(2224.)

75. Model, in Wood. Calcining Furnace.

Schroeder, Darmstadt.—(2251.)

76. Model, in Wood. Coking Furnace.
Schroeder, Darmstadt.—(2252.)

77. Model, in Wood. Charcoal, Annealing Furnace.
Schroeder, Darmstadt.—(2283.)

Note.—The foregoing ten models in wood, of furnaces for various manufacturing purposes, take to pieces, and show sections, interior elevations, and other detail of their arrangements, and principles.

78. Model, in Wood. Steam Boiler. German form, showing setting.
Schroeder, Darmstadt.

Note.—This model takes to pieces, and shows in section the fire-grate arranged for consuming smoke. The position and distribution of the flues around the boiler, and their final exit to chimney. The fire-grate which is of great length is arranged in banks or layers; the fuel is supplied to the fire at the front end by a hopper, and the products of combustion pass over the bright fire at the back end of the grate. The boiler is that known technically as the "Elephant" form of boiler.

79. Models, in Wood (3), representing specimens of Brickwork Construction; in "English" and "Flemish" bond.
Schroeder, Darmstadt.

Note.—These models represent wall elevations, and details of window heads, archwork, &c.

80. Photographs, of Models of Mechanism (3). Framed and glazed, (20 × 15 inches, 26 × 21 inches, and 21 × 17 inches.)
Schroeder, Darmstadt.

Note.—The whole of the foregoing series of models and photographs of mechanism and building construction were purchased from Mr. James Schroeder, Darmstadt, at the Paris Exhibition 1867. Price 333*l.*, including a set of drawing models, representing carpentry and joinery, for roofs, and other general work. The whole series forms part of the Educational Division of the Museum; from which it was transferred. 1877.

Models of Mechanism. English Manufacture.

1. Working Models of Lift Pumps. (Two.) The barrels of glass. The piston rods and fittings in brass.
Newton and Co., Fleet Street, E.C.

2. WORKING MODEL of a Force Pump. The barrel and air-vessel of glass; the plunger rod and fittings in brass.

Newton and Co., Fleet Street, E.C.

Note.—There are three lengths of pipe in glass, to illustrate the lifting of the water. The top of the air-vessel is fitted with a nozzle pipe on ball and socket joint, to illustrate the principles of a fire-engine.

3. WORKING MODELS, in Brass. Oscillating Cylinder Steam Engine, Locomotive Engine.

Newton and Co., Fleet Street, E.C.

4. WORKING MODEL, in Wood and Metal, by Professor Willis. Variable Link-work.

Note.—The model illustrates the mode by which the path of a reciprocating piece may be increased or diminished or entirely stopped without varying or stopping the prime mover.

5. WORKING MODEL, in Metal. Hooke's Joints; better known as universal joints. To show the effects of different inclinations of the axes, and marked discs to show the relative velocities in each portion of a rotation.

Prof. Willis.

Note.—Hooke's joints are often applied in practice to drive shafting or machinery in oblique direction to the main force.

6. TWO LAY FIGURES, in Wood, to illustrate the mechanical positions of the human body when carrying weights, and to illustrate the centre of gravity.

Prof. Willis.

7. WORKING MODEL, in Wood. Compound Lever.

Prof. Willis.

8. PATENT LOCK and Key. Tucker and Reeve's patent, 1855. Size, $4\frac{1}{2} \times 2\frac{1}{2}$ inches.

Presented by the late Captain F. Fowke, R.E.

9. VAPOUR BATH. Copper. R. Moss' patent, 1851. The bath is worked by a spirit lamp, and has a set of tube connections for dispersing the vapour. It was shown at the Great Exhibition of 1851.

10. WORKING MODEL, in Wood. Chinese Chain Pump; horizontal action; worked by the feet, similar to a "tread-mill."

Made at the Penal Establishment, Pentridge, Australia.

11. WORKING MODEL of a Guillotine. To illustrate one used at Athens in June 1870. Scale 1 inch to 1 foot.

Presented by Lieut. J. C. Symons.

The preceding models of mechanism of English make were transferred from the Educational Division of the Museum. 1877.

MODELS OF MECHANISM IN METAL AND WOOD.

Selected by Professor Unwin for circulation amongst Science Schools and Classes for instruction in the theory and practice of mechanical engineering.

The Numbers in brackets refer to the Price Lists of the Makers of the Models as furnished to the Science and Art Department.

1. WORKING MODEL, in Wood. Hanger or Bracket for driving shafts; for bolting to wood beam. The cap kept in place partly by a bolt and partly by a steel key.

Prof. Unwin. Schroeder, Darmstadt.—(21.)

2. WORKING MODEL, in Wood. Wall Brackets for shafts. Upper and lower brass steps, cap and needle lubricator. The bracket plate wedged up by steel keys.

Prof. Unwin. Schroeder, Darmstadt.—(22.)

3. WORKING MODEL, in Wood. Plummer Block or Pedestal for shafts; with cap, brass steps, and wall plate, locking nuts on cap bolts. The wall plate permits the adjustment of the pedestal laterally. It is adjusted vertically by hard wood packing.

Prof. Unwin. Williamson, Kendal.—(26.)

4. WORKING MODEL, in Wood. Muff or Box Coupling. The shafts without bosses or neck at ends, sunk key-way and key.

Prof. Unwin. Williamson, Kendal.—(16.)

5. WORKING MODEL, in Wood. Half-lap Coupling. The shafts with bosses and neck.

Prof. Unwin. Williamson, Kendal.—(17.)

6. WORKING MODEL, in Wood. Flange Coupling. Bolts sunk into flanges. Nuts loosened by box key. Shafts with bosses, key-ways and keys.

Prof. Unwin. Williamson, Kendal.—(18.)

7. WORKING MODEL, in Wood. Disengaging Coupling or Clutch for shafts.
Prof. Unwin. Schroeder, Darmstadt.—(19.)

8. WORKING MODEL, in Wood. Section of a Spur Wheel; showing part of arm, rim, and teeth.
Prof. Unwin. Schroeder, Darmstadt.—(23.)

9. WORKING MODEL, in Wood. Section of Mortice Spur Wheel; showing arm, boss or nave, part of rim, and wooden teeth.
Prof. Unwin. Williamson, Kendal.—(26.)

10. WORKING MODEL, in Wood. Section of Mortice Spur Wheel; showing part of rim, teeth, one arm, and nave.
Prof. Unwin. Williamson, Kendal.—(.)

11. WORKING MODEL, in Wood. Section of Bevel Wheel and Pinion; showing one arm, nave, rim, and teeth of both.
Prof. Unwin. Williamson, Kendal.—(25.)

12. WORKING MODEL, in Wood. Driving Cone for differential speed.
Prof. Unwin. Williamson, Kendal.—(.)

13. WORKING MODEL, in Wood. Half full size. Showing part of a steam engine Piston-rod; with cross-head, slide block, and slide bars. Also part of connecting-rod, with forked end, straps with gibs and cotters.
Prof. Unwin. Williamson, Kendal.—(37.)

Note.—This model represents the arrangement for a horizontal engine.

14. WORKING MODEL, in Wood. Solid Connecting Rod End. Half full size. The brasses adjusted by sliding wedge, moved by a screw.
Prof. Unwin. Williamson, Kendal.—(34.)

15. WORKING MODEL, in Wood. Connecting Rod End; ordinary form.
Prof. Unwin. Williamson, Kendal.—(36.)

16. WORKING MODEL, in Wood. Cast-iron Engine Crank and part of shaft. The crank held in place by sunk key-way on shaft, and steel key; crank-pin made taper, and fixed by a pin, through pin and crank-head.
Prof. Unwin. Schroeder, Darmstadt.—(29.)

17. Working Model, in Wood. Cast-iron Crank, and part of shaft. Crank-pin fixed by shrinking and rivetting. Shaft with boss, key-way, and neck. Half full size.
Prof. Unwin. Williamson, Kendal.—(30.)

18. Working Model, in Wood. Part of wrought-iron Cranked Shaft. Diameter of shaft 5 inches; throw of crank 9 inches. Half full size.
Prof. Unwin. Williamson, Kendal.—(32.)

19. Working Model, in Wood. Steam-engine Piston. Steel ring packing.
Prof. Unwin. Williamson, Kendal.—(39.)

20. Working Model, in Wood. Cylinder Cover; piston-rod, stuffing box, and gland. Also, part of end of cylinder showing steam-way. Bolts and nuts. Faced joints.
Prof. Unwin. Williamson, Kendal.—(38.)

21. Working Model, in Wood. Full size. Eccentric (wheel) for locomotive engines. The cam cast in halves, which are connected by studs and cotters. Set-screws, and key for fixing on shaft. The eccentric ring of brass, and strap of wrought-iron, lock nuts to bolts, and syphon oil cup. The eccentric rod is T-ended with lock nuts and split pins.
Prof. Unwin. Williamson, Kendal.—(.)

22. Working Model, in Wood and Metal. Air-Pump Valve. Half full size. Brass grating, brass guard, india-rubber valve.
Prof. Unwin. Williamson, Kendal.—(40.)

23. Working Model, in Wood. Gland Steam Cock. Full size. This model will take to pieces, and show internal section and construction.
Prof. Unwin. Williamson. Kendal.—(41.)

24. Model, in Wood. Cylinder Cover Joint. Joint faced. The cover fits into cylinder to prevent play.
Prof. Unwin. Schroeder, Darmstadt.—(12.)

25. Working Model, in Wood. Bolt and Nut Connections. Twelve Illustrations on a board. Used for iron, wood, and stone work.
Prof. Unwin. James Rigg, Chester.—(5.)

26. Working Model, in Wood. Cast-iron Tank Joints. Four bottom plates; inside flanges, with nuts and bolts. Rust-cement joints.
Prof. Unwin. J. Rigg, Chester.—(6.)

27. WORKING MODEL, in Wood. Four Bottom Plates of a cast-iron Tank, with outside flanges. Nuts and bolts. Caulked from the inside. Rust-cement joints.
Prof. Unwin. J. Rigg, Chester.—(7.)

28. WORKING MODEL, in Wood. Corner Joint formed by three plates of a cast-iron Tank. Outside flanges. Nuts and bolts. Caulking inside.
Prof. Unwin. J. Rigg, Chester.—(8).

29. WORKING MODEL, in Wood. Two Plates of wrought-iron; single rivetted with a lap joint. The rivets with common snap heads.
Prof. Unwin. J. Rigg, Chester.—(1.)

30. WORKING MODEL, in Wood. Two wrought-iron Plates, showing double rivetted lap joint.
Prof. Unwin. J. Rigg, Chester.—(2.)

31. MODEL, in Wood. Two wrought-iron Plates; showing butt joint with covering strip, single rivetted.
Prof. Unwin. J. Rigg, Chester.—(3.)

32. MODEL, in Wood. Two wrought-iron Plates; showing T-iron joint. The covering strip in No. 3 is here replaced by a T-iron, which stiffens the plates materially.
Prof. Unwin. J. Rigg, Chester.—(4.)

33. MODEL, in Wood. Corner Joint for Cast-Iron Plates. Projecting lugs instead of flanges. The joints faced.
Prof. Unwin. Schroeder, Darmstadt.—(10.)

34. MODEL, in Wood. Corner Joint Cast-Iron Tank plates. Shewing three plates with flanges and chipping strips. Rust joint caulked from outside. Nuts and bolts, flanges thickened for stiffness.
Prof. Unwin. Schroeder, Darmstadt.—(11.)

35. MODEL, in Wood. Tank joint. Faced Joint. Outside flanges.
Prof. Unwin. Schroeder, Darmstadt.—(13.)

36. MODEL, in Wood. Tank Joint. Corner joint. Cast-iron plates; outside flanges. Faced joints. The flanges thickened for stiffness. Bolts and nuts.
Prof. Unwin. Schroeder, Darmstadt.—(14)

Note.—These models of mechanism, chiefly of English manufacture, were selected for students' instruction by Professors Unwin and Willis, and made under their direction by Messrs. James Rigg, of Chester, and Williamson Brothers, of Kendal. They form part of the Educational Division

of the Museum, from which they were transferred to Machinery Collection in 1877.

MODELS DESIGNED BY PROFESSOR WILLIS IN 1857.

For teaching principles of Mechanics and Mechanism in Schools and Colleges.

Transferred from Educational Collection. 1877.

1. STATICS.—Mechanical Powers. LEVER. Stand; two counterpoise levers; balanced lever, divided into 2-inch parts; two wire pins for supporting levers; four hooks, and Archimedian lever.
Prof. Willis.—1857.

2. WHEEL and AXLE. Cardboard disc, 1 foot 3 inches in diameter; wooden stand; two strings for supporting weights 3 feet long, and two 1 foot 6 inches long, one brass pin.
Prof. Willis.—1857.

3. PULLEY. One cross-bar to fasten pulley posts, two three-sheaved, two two-sheaved, and one one-sheaved pulley; one moveable pulley.
Prof. Willis.—1857.

4. INCLINED PLANE. Graduated plane, with variable sides; two pulley posts; one moveable pulley; lead roller $\frac{3}{4}$ inches in diameter, and $2\frac{1}{2}$ inches long, weight five-tenths of a pound.
Prof. Willis.—1857.

5. WEDGE. Wooden frame, and two wedges; weight of each, five-tenths of a pound.
Prof. Willis —1857.

6. SCREW. Two tin screws; one 8 inches in diameter, and one 4 inches in diameter, with wooden stand, pulley post, working screws, &c.
Prof. Willis.—1857.

7. SUNDRIES belonging to the above set of models. Three cast-iron tripods for supporting apparatus; three $\frac{5}{8}$-inch bolts and winged nuts; boards, pulleys, weights, &c. Frame and strings to illustrate the parallelogram of forces.
Prof. Willis.—1857.

8. LAY FIGURES to show the position of the human body when carrying loads, and to illustrate the centre of gravity.
Prof. Willis.—1857.

9. PASTEBOARD PARALLELOPIPED; to demonstrate the method of obtaining the resultant of three forces not in the same plane.

10. A SET OF APPARATUS to demonstrate and illustrate the construction, pressures, and tensions of the three leg-shears, and derrick. Also to show the amount of pressure upon each of the three legs of a table.

11. DYNAMICS.—DROP-BOX to let fall simultaneously two large Balls of cork and lead.

Prof. Willis.—1857.

12. KINEMATICS.—VARIABLE Link-Work; showing a mode by which the path of a reciprocating piece may be increased, or diminished, or entirely suspended, without altering or stopping the prime mover

Prof. Willis.—1857.

13. COMBINATION of Hooke's Joints; showing the effects of different inclinations of the axes, and supplying means for observing the relative velocities in each portion of the rotation.

Prof. Willis.—1857.

14. SPECIMENS of pieces that admit of being put together at pleasure, to form framework for mechanical combinations, philosophical apparatus, or the support of diagrams and other objects, either for exhibition in lectures, the performance of experiments, or the trial of new combinations. These pieces are described at length in Willis's "System of Apparatus, &c."

Prof. Willis.—1857.

Note.—As an example of the above system, some of these pieces are combined in the form of a model of link-work connecting two parallel axes. The objects form part of the Educational Division of the Museum, from which they were transferred in 1877.

SERIES OF SECTIONAL MODELS, in Wood. APPLIED MECHANICS AND MACHINERY.

Constructed by Mr. James Rigg, C.E., Chester; for use in Science Schools and Classes.

Transferred from the Educational Division, 1877.

1. WORKING MODELS, in Wood. Set of three. Eccentric and Elliptic Toothed Wheels.

Mr. J. Rigg, Chester.

2. WORKING MODEL, in Wood. Conical Toothed Wheel, and Toothed Cone, upon Roemer's principle to produce varying velocity.

Mr. J. Rigg, Chester.

3. Working Model, in Wood. Hindley's Worm Wheel, and Worm, having many teeth in contact.
Mr. J. Rigg, Chester.

4. Working Model, in Wood. Screw, Returning into itself.
Mr. J. Rigg, Chester.

5. Sectional Working Model, in Wood, of a Water Gas-Meter; for elementary instruction.
Mr. J. Rigg, Chester.

6. Working Model, in Wood, illustrating the principle of Calculating Machines, for addition and subtraction.
Mr. J. Rigg, Chester.

7. Working Model, in Wood. Diagram of a Lift Pump; the valves being arranged to open and close so that their action may be clearly seen.
Mr. J. Rigg, Chester.

8. Working Model, in Wood. Diagram of a Door Lock and Key; showing the mode in which the various parts, are arranged, and how the key moves the tumblers.
Mr. J. Rigg, Chester.

9. Working Model, in Wood. Diagram of a Steam Engine; which can be placed before a Class either as a horizontal, vertical, marine, or locomotive engine.
Mr. J. Rigg, Chester.

10. Sectional Working Model, in Wood, of a Steam Engine. Designed by Professor Cowper.
Mr. J. Rigg, Chester.

11. Sectional Working Model, in Wood, of an Oscillating Cylinder Steam Engine. Designed by Professor Cowper.
Mr. J. Rigg, Chester.

12. Working Model, in Wood. Reciprocating Bar and Frame, to make apparent the consequences of circular motion when converted by means of link-work into linear motion. As for example, in the eccentric and slide valve of a steam engine.
Mr. J. Rigg, Chester.

13. Two Working Models, in Wood, illustrating the Parallel Motion of small steam engines; for elementary instruction.

Mr. J. Rigg, Chester.

14. Working Model, in Wood, illustrating the Parallel Motion of a Marine steam engine; for elementary instruction.

Mr. J. Rigg, Chester.

15. Working Model, in Wood, illustrating the Parallel Motions of a Beam land steam engine; for elementary instruction.

Mr. J. Rigg, Chester.

16. Working Model, in Wood, to illustrate the various conditions of Wrapping Contact, or endless-band motions.

Mr. J. Rigg, Chester.

17. Two Working Models, in Wood, illustrating Intermittent Motion, by hoop and pin wheel.

Mr. J. Rigg, Chester.

18. Working Model, in Wood, to illustrate Intermittent Motion produced by link-work.

Mr. J. Rigg, Chester.

19. Working Model, in Wood, to illustrate Rotary or Oscillating Motions, with varying velocities; produced by an eccentric pin and slit bar.

Mr. J. Rigg, Chester.

20. Working Model, in Wood, to illustrate Rotary or Oscillating Motions with varying velocities produced by link-work.

Mr. J. Rigg, Chester.

21. Working Model, in Wood, of Link-Work to show Boehm's motions; by which means three straight bars and two face-plates communicate equable rotation from one shaft, to another parallel thereto.

Mr. J. Rigg, Chester.

22. Working Model, in Wood, to illustrate Transmission of Axial motion by means of a face plate, with cross grooves.

Mr. J. Rigg, Chester.

23. WORKING MODEL, in Wood, illustrating a Cam; arranged in the form of a groove on the face of a wheel.
Mr. J. Rigg, Chester.

24. SECTIONAL WORKING MODEL, in Wood and Metal, of a Thrashing Machine for grain; for elementary instruction. Showing the mode in which the grain is separated from the ear;—then from either long or short straw; and prepared for the winnowing machine and corn flour mill.
Mr. J. Rigg, Chester.

25. SECTIONAL WORKING MODEL, in Wood and Metal, of a Winnowing Machine for grain; for elementary instruction. Showing the mode in which the chaff and very small seeds are separated from the grain, and the grains are distributed into firsts and seconds; the corn is thus prepared for the flour mill.
Mr. J. Rigg, Chester.

26. SECTIONAL WORKING MODEL, in Wood and Metal, of the Interior of a Corn Mill. For elementary instruction. Showing the mode in which the corn is supplied to the millstones. "Ground," "Passed along," "Elevated," "Dressed," and put into sacks as flour for use.
Mr. J. Rigg, Chester.

27. WORKING MODEL, in Wood. ($\frac{1}{8}$ of full size). Illustrating the principle of the Machine for Mortising timber for doors, gates, windows, &c. For elementary instruction in the use and power of combinations of levers.
Mr. J. Rigg, Chester.

28. WORKING MODEL, in Wood, of a Boiler-plate Punch; showing how, by a properly constructed cam, the greatest power of the machinery may be applied in the act of punching.
Mr. J. Rigg, Chester.

29. WORKING MODEL, in Wood and Metal, to illustrate the actions of the Electric Telegraph. The one side showing how the currents are reversed, and the other how consequently signals may be transmitted. The arrows show the direction of the currents.
Mr. J. Rigg, Chester.

30. WORKING MODEL, in Wood and Metal, illustrating the Hammer action of a Pianoforte.
Mr. J. Rigg, Chester.

31. WORKING MODEL, in Wood. Motions illustrating the Pedal of the Harp.

Mr. J. Rigg, Chester.

32. WORKING MODEL, in Wood. The Wedge. Wooden frame, and two wedges. (Part of kinematical apparatus by Professor Willis.)

Mr. J. Rigg, Chester.

ALPHABETICAL INDEX TO EXHIBITORS AND SUBJECTS IN THE CATALOGUE OF THE COLLECTION OF MODELS OF MACHINERY, DRAWINGS, &c. IN THE SOUTH KENSINGTON MUSEUM.

*** *The numbers in this Index refer to pages only.*

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APPENDIX.

Class I. No. **212.** PAPER-CENTRE RAILWAY CARRIAGE WHEEL. Allen's Patent, 1875.

Lent by Messrs. John Brown and Co., Limited, Atlas Works, Sheffield. 1879.

Note.—The entire centre of this wheel is made of coarse paper compressed by hydraulic power into a solid mass resembling wood. A portion of the wheel face is removed to show its interior, and a block of the compressed paper is exhibited.

Class I. No. **213.** DEAD-WEIGHT SAFETY VALVE, for BOILERS. Full size. Eaves' Patent.

Lent by Messrs. John Brown and Co., Limited, Atlas Works, Sheffield. 1879.

Note.—The valve is formed by a perfect sphere seated on hardened steel. The frame carrying the valve weights is suspended by a concave centre-piece lined with soft metal protecting the valve sphere from injury, and allowing the weights to hang perfectly free and plumb.

Class I. No. **214.** Set of ENGINE-ROOM TELEGRAPHS. Full size. In working order.

Lent by Messrs. Chadburn and Son, Lord Street, Liverpool. 1878.

Note.—These telegraphs for conveying orders to engine-rooms, are constructed with a single action or with a repeating action, so that orders may be replied to.

Class I. No. **215.** Set of SHIP'S STEERING TELEGRAPHS. Full size. In working order.

Lent by Messrs. Chadburn and Son, Lord Street, Liverpool. 1878.

Note.—The telegraph repeats to the officer of the ship the orders which he has conveyed to the helmsman.

Class I. No. **216.** WORKING MODEL. Hot water boiler. E. G. Rivers' Patent, 1878.

Lent by Messrs. James Simpson and Co., Engineers, Grosvenor Road, S.W. 1879.

Note.—The boilers may be described as saddle tubular boilers. The tubes are 7 feet in length, of a ⊐ shape. The upper portion forms the flow, the lower portion forms the return. The arrangements of this boiler admit of the tubes being constantly inspected, and easily removed in case of accident.

Class IX. No. **42.** Series of COLOURED DRAWINGS, framed and glazed. Early steam engines and machines.

Lent by Mr. Bennet Woodcroft, F.R.S., 30, Redcliffe Gardens, S.W. 1876.

Note.—The following early steam machines and engines are represented :—Engine by Hero of Alexandria, B.C. 130. Engine by Solon de Caus, 1612. Giovanni de Branca, 1629. Torricelli, 1643. Otto Guericke, 1650. Marquis of Worcester, 1663. Denis Papin, 1690. Thomas Savery, 1698. Guillaume Amontons, 1699. Thomas Newcomen, 1710, 1712, 1718. Leopold, 1720. James Watt, 1769, 1782, 1788, 1790, 1802. James Pickard, 1780. Patrick Miller, 1787. W. Symington, 1787-8. Edmund Cartwright, 1797. Fenton and Murray, 1802. H. Maudslay, 1807.

Class IX. No. **43.** DRAWINGS of MACHINERY. LITHOGRAPHS and ENGRAVINGS.

Lent by the late Mr. Bennet Woodcroft, F.R.S., 30, Redcliffe Gardens, S.W. 1877.

Note.—These Drawings illustrate amongst others the following machines. A Newcomen engine, 1712. Symington engine, 1787. The early locomotives "Rocket," "Novelty" and "Sans Pareil," 1829. Whitworth's Self-acting Slide Lathe, 1840, and Whitworth's Self-acting Planing Machine with automatic tool reversing motion, 1840.

Class I. No. **217.** MODEL, in WOOD; illustrating Halpin's Patent Equilibrium Slide Valve for Steam Engines.

Lent by Mr. D. Halpin, 7, Thornfield Road, Shepherds Bush. 1879.

Note.—The model shows a horizontal steam cylinder, and the construction of Halpin's Equilibrium Slide.

Class VIII. No. **17***a*. DRAWINGS and ENGRAVINGS. Three in number. Early Engineering Works.

Lent by Mr. Bennet Woodcroft, F.R.S., 30, Redcliffe Gardens, S.W. 1876.

Note.—The following works are represented :—Engraving, Iron Bridge, 236 feet single span over the River Wear at Sunderland, 1796; T. Wilson, engineer. Pencil sketch, bow and string bridge system; A. Nasmyth, 1796. Engraving, proposed bridge of cast-iron, single span 600 feet, over River Thames ; Telford and Douglass, engineers, 1800.

Class I. No. **98***a*. DRAWINGS, framed and glazed. Early Screw Propellers applied to the propulsion of ships.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—Coloured drawing of H.M.S. "Dwarf," fitted with Woodcroft's screw propeller, 1840–43; details of the screw. Pencil sketch, screw propellers designed by A. Nasmyth, 1819.

Class IX. No. **45.** DRAWINGS, framed and glazed. Early Steam Vessels.

Lent by Mr. Bennet Woodcroft, F.R.S. 1876.

Note.—Coloured drawing, triple hull paddle-wheel boat. Patrick Miller, 1786. Lithograph, through section; W. Symington's steamboat, 1787–8. Lithograph, elevation of Mr. Symington's engine, 1787–8. Coloured drawing, early stern wheel steamboat. Pen and ink sketch, plan and through seetion of the paddle-wheel steamer designed in 1783 by the Marquis de Jouffroy, Lyons.

Class 1. No. **49***a*. DRAWING. Coloured drawing, scale 1 inch to 1 foot, showing front elevation and end elevation of the vertical engines, on the trunk system, 450 nominal horse power, for the Peninsular and Oriental screw steamship "Candia," 2,100 tons. Messrs. J. and G. Rennie, Engineers.

Lent by the Peninsular and Oriental Steam Navigation Co., 122, Leadenhall Street, E.C. 1879.

Note.—The engines illustrated by this drawing were designed and constructed in 1854, by G. Rennie and Co., Blackfriars, for the P. and O. screw steamship "Candia." The engines had vertical fixed cylinders driving an overhead shaft, the screw of the ship being driven by multiplied gear.

Class I. No. **217.** MODEL. Cross sectional working model of a passenger railway carriage, illustrating Stewart's Patent Alarm Signal and Communication between passengers, guards, and engine-drivers of railway trains.

Presented by Mr. Charles Stewart, M.A., 50, Colebroke Row, N. 1879.

Prime Movers.—Class I.

The principal forms of prime movers used for all kinds of purposes in which steam power is employed may be divided into three sorts:

1. *Beam Engines.*

The beam of the engine rocks or vibrates equally on the centre of its length; or the beam of the engine is fixed at one end and driven upwards and downwards by the steam cylinder and piston at the other, a form known as the grasshopper engine.

2. *Vertical Engines.*

In the vertical engine the crank shaft and fly-wheel are often carried overhead on the engine framing, the cylinder being directly underneath; or, as in the present more modern form, the cylinder is inverted and carried on the top of the engine frame, whilst the crank shaft and fly-wheel lie directly underneath close to the ground. Engines having oscillating cylinders are also used.

3. *Horizontal Engines.*

In the horizontal form of engine, the cylinders lie on their sides and drive their crank shaft and fly-wheel in a direct line.

Vertical, horizontal, or inclined engines are used chiefly where space is limited in quantity and of serious moment.

The philosopher, Hero of Alexandria, who flourished 281–241 B.C., is credited with the invention of the first steam engine or machine moved by steam.

Edward Somerset, second Marquis of Worcester, 1601–1667; Thomas Savery, 1698; Thomas Newcomen, 1712; James Watt, 1736–1819; Hornblower, 1776 and 1781; Heslop, 1790; Fenton and Murray, 1802; H. Maudslay, 1807; are some of the celebrated names connected with the early invention, improvement, and application of the steam engine in England.

LONDON:
Printed by George E. Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.
[16093.—500.—2/80.]

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